JPL PUBLICATION 85-43, VOLUME I

Total-Dose Radiation Effects Data for Semiconductor Devices

1985 Supplement

Keith E. Martin
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William E. Price

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October 15, 1985

NASA

National Aeronautics and
Space Administration

Jet Propulsion Laboratory
California Institute of Technology
Pasadena, California

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ABSTRACT

This document provides steady-state, total-dose radiation test data, in graphic format, for use by electronic designers and other personnel using semiconductor devices in a radiation environment. The data were generated by JPL for various NASA space programs. The document is in two volumes: Volume I provides data on diodes, bipolar transistors, field effect transistors, and miscellaneous semiconductor types, and Volume II provides total-dose radiation test data on integrated circuits.

Volume I of this 1985 Supplement contains new total-dose radiation test data generated since the August 1, 1981 release date of the original Volume I, JPL Publication 81-66.

Volume II of the 1985 Supplement will be published at a later date.

INDEX OF DEVICE TYPES

VOLUME I

Device Type	Device Number	Vendor[a]	Page	Device Number	Vendor[a]	Page
Diodes	MZ4626	MOT	6-3	S02048	SCN	6-7
Bipolar Transistors	2N918	MOT	6-11	2N3019	MOT	6-35
	2N1304	TIX	6-12	2N3350	MOT	6-36
	2N2222	MOT	6-16	2N3501	MOT	6-37
	2N2222	RAY	6-17	2N3637	MOT	6-40
	2N2369	MOT	6-18	2N3700	NSC	6-42
	2N2432	TIX	6-19	2N3799	TIX	6-45
	2N2484	MOT	6-21	2N3964	MOT	6-46
	2N2658	SOD	6-22	2N4150	SOD	6-47
	2N2907	MOT	6-23	2N4150	UTR	6-53
	2N2907	RAY	6-24	96EJ103	SOD	6-56
	2N2907	TIX	6-25	MQ2219	MOT	6-58
	2N2920	MOT	6-27	SDT3323	SOD	6-59
	2N2920	RAY	6-30	SDT3423	SOD	6-61
	2N2920	TIX	6-31			
Field-Effect Transistors	2N4338	SIL	6-64	IRF150	INR	6-75
	2N4391	SIL	6-65	J230	SIL	6-90
	2N4391	MOT	6-67	U401	SIL	6-92
	2N4867	SIL	6-72	U423	SIL	6-104
Optical Devices	TIL24	TIX	6-109			

[a]See Appendix A for Vendor Identification Code.

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APPENDIXES

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<u>Table</u>

SECTION I

INTRODUCTION

The data presented in this report describe the results of Total Ionizing Dose (TID) tests of semiconductor devices (Volume I) and integrated circuits (Volume II). The data were obtained by the Jet Propulsion Laboratory (JPL), under contract to NASA, in order to assure the "hardness" (radiation resistance) of components to be used in a variety of radiation environments. However, the data are applicable to any ionizing radiation environment. Two primary radiation sources were used: a Cobalt-60 gamma ray source and a 2.5 MeV electron Dynamitron. Irradiations of complex ICs were subcontracted to the Boeing Radiation Effects Lab (BREL), Seattle, Washington, where the necessary computerized test equipment was available, but the work was subject to JPL specifications and procedures. The data presented here (Volume I of the 1985 Supplement) are primarily in a graphic format for various device operating conditions as a function of dose. Some measure of the statistical variations of each device lot is provided by the tabulated standard deviations and a statement of sample size. Irradiations of different lots of a given device type are treated as separate tests.

In Volume II, the information on some integrated circuits is presented in tabular format. For more complex large-scale integration (LSI) devices, the data are given in a narrative form, which gives proper emphasis to the radiation-induced changes in measured parameters. Volume II of the 1985 Supplement will be published at a later date.

All data taken here substantially meet the specifications of MIL-STD-883, Method 1019.1 for environments where short-term annealing is not a relevant problem. Three or more radiation levels at room temperature were performed, with electrical parameter measurements typically taken within 20 minutes of the completion of an irradiation, and a worst-case bias for JPL's systems applications sustained during irradiation.

An additional publication is scheduled for release in late 1986. This publication will present design guidelines regarding Single Event Upset (SEU) phenomena in high-energy-particle radiation environments. The original Volume III published in 1981 will not be updated.

SECTION II

DOCUMENT USES AND LIMITATIONS

The purpose of this report is to provide test data for semiconductor devices exposed to a steady-state TID irradiation. As such, it offers a useful radiation response comparison of different devices that might be considered in the development (circuit design) of a radiation-hardened system. It also offers a quick method for assisting an engineer to determine the weak links in an existing system, and the maximum radiation tolerance of the system as a whole.

The data presented here cannot, in any way, be used as a substitute for a comprehensive testing program of the devices actually used in a given system, but is intended as a useful guideline for device selection. It will be clear on inspecting the data that there are large lot-to-lot, or wafer-to-wafer, variations in the sample response of a given device type. The difference in response from functionally identical devices fabricated by different manufacturers is, of course, much greater. There was no attempt to remove maverick (outlier) devices from the data plots; thus, some data plots may appear anomalous when compared to other plots for the same device type. Finally, there is always the likelihood that given manufacturers will make minor adjustments in their processing procedures that will result in major differences in device radiation response.

SECTION III

GENERIC DEVICE TYPE INFORMATION

Some generalized comments appropriate to each generic device type are provided in the following subsections, and a description of vendor identification codes is provided in Appendix A. The mean of the electrical parameters measured for each generic device type is given on the ordinate of the graphs, and a detailed description of these parameters is provided in Appendix B.

A. DIODES

Radiation tests of diodes have been very limited for space programs because of the inherent radiation hardness at the total dose level of 300 krad(Si) (Galileo Project specification). However, testing may be required for special high-precision applications or for higher total-dose environments where large (orders of magnitude) increases in the leakage current can be expected.

B. BIPOLAR TRANSISTORS

For convenience, the degradation in transistor gain (h_{FE}) is plotted as $\Delta(1/h_{FE}) = 1/h_{FE\phi} - 1/h_{FEo}$, where $h_{FE\phi}$ is the value at the specified radiation level, and h_{FEo} is the initial value. Implicit in this approach is the assumption that the radiation behavior can be approximated by the well-known formula:

$$\Delta(1/h_{FE}) = K\phi$$

where ϕ is the dose (or fluence) and K is a damage constant that depends on the device and collector current, I_C.

C. FIELD EFFECT TRANSISTORS (FETs)

Junction-gate field effect transistors (JFETs) have a considerably higher tolerance to radiation-induced bulk damage than bipolar transistors because they are majority-carrier devices. Therefore, most tests were conducted using electron irradiations. Key parameters plotted as a function of dose include I_{GGS}, I_{DSS}, V_{GS}, transconductance, noise voltage, and I_D (off). (See Appendix B.)

D. OPTICAL DEVICES

The optical device type is an infrared-emitting diode (IR-LED). The emission efficiency of GaAs LEDs is greatly reduced by irradiation.

SECTION IV

RADIATION SOURCES AND DOSIMETRY

A. DYNAMITRON

The Dynamitron accelerators at JPL and BREL provide a 2.5-MeV beam with a beam-current range of 10^8 to 10^{10} electrons/cm^2/sec. All tests described here were irradiated with exposure times between 5 and 45 minutes.

The test geometry for the two Dynamitrons is essentially the same in that the electron beam reaches the devices after passing through a 0.05-mm titanium window, copper and aluminum scattering foils, and 0.9 m of air. Each of these materials scatters the electrons slightly so the beam has a reasonable uniformity (< 20%) over the device array under test. The device array is confined within a 25-cm-diameter circle perpendicular to the beam direction, and at the center of this circle is the aperture of a vacuum Faraday cup, which is used to control the electron-beam flux and fluence. The beam is centered on the Faraday cup with a quadrupole magnet prior to the installation of the test samples, and the Faraday cup output current fed into a current integrator, which is calibrated daily with a calibrated current source. The integrator is set to automatically shut off the electron beam when the desired fluence level is received by the Faraday cup.

B. COBALT-60 SOURCES

The Cobalt-60 gamma ray sources at JPL and BREL were both used. The gamma rays consisted primarily of 1.17 and 1.33 MeV photons with a consistent spectrum of lower-energy photons and secondary electrons arising from scattering and absorption. The gamma field was uniform within ±10 percent in the area where parts were exposed, which was verified by thermoluminescent dosimetry (TLD), consisting of lithium fluoride/Teflon microrods. The main source

calibration was performed with Landsverk ion chambers of ±2 percent accuracy, traceable to the National Bureau of Standards, and monthly dose rate computations were performed to account for the Cobalt-60 decay. Exposure times with the Cobalt-60 sources were typically 5 to 20 minutes for each radiation level, but longer times (up to 4 hours) were required for high-dose applications because the maximum uniform dose rate available was 50 rads/second.

SECTION V

TEST SETUP AND PROCEDURES

A. GENERAL REMARKS

The test setup and procedures used to gather these data were developed in accordance with MIL-STD-883 specifications. All tests were done at $25^{o}C \pm 3^{o}C$, using low noise power sources and instrumentation subject to periodic calibration. Some tests were performed *in situ* (without removing the test devices from the radiation area), whereas others required remote testing. In the latter event, a mobile bias fixture was used to maintain bias, except during the brief measurement period.

A detailed test plan was written for each test. This plan included device description, irradiation bias conditions, radiation levels, electrical parameters to be measured, and measurement conditions. The data were processed by both hand and computer, and the calculation of normal standard deviations was made after deletion of clearly erroneous data. Each graph has a log number and can be retrieved if required by specifying the log number to the Radiation Effects Group (Section 514) at JPL.

B. TESTING WITH A MATRIX BOARD

A matrix board switching system was built to be used as a master control panel and was set up outside the irradiation area. The matrix board interfaces the devices under test (DUT) to the power supplies and measurement equipment via a special 15-meter (50-foot), double-shielded cable (see Figure 1). A built-in potentiometer for each DUT can be used to control bias voltages and currents. The matrix board was designed with very high insulation resistance so that very low current measurements (10-50 pA) can be made. When not being tested *in situ*, devices are removed from the radiation area for measurements.

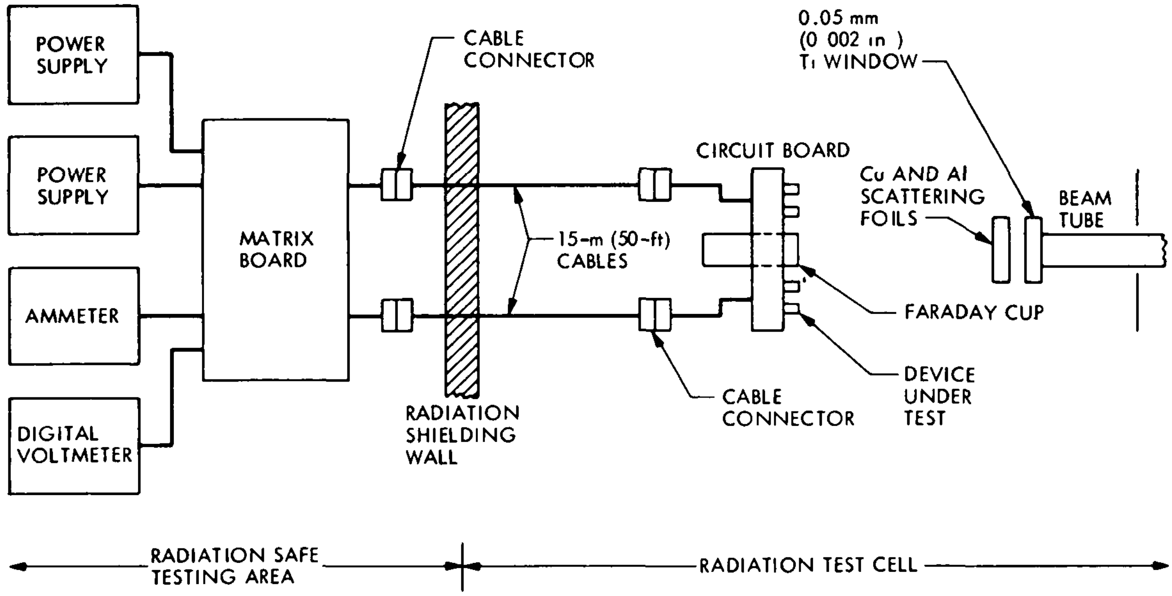


Figure 1. Diagram of the Test Setup for Dynamitron Testing

C. TESTING WITHOUT A MATRIX BOARD

For tests that are not in situ, the DUTs are removed from the site for approximately 20 minutes between each radiation level. A mobile bias (battery) is applied to the devices at all times except during parameter measurements. Remote measurements include tests at a Lorlin Impact 100 pulsed tester for some of the transistors, and readings from a Tektronix 178/577 curve tracer for testing some operational amplifiers. Occasionally, custom test circuits are used in the test to simulate the device application.

D. TESTING AT BREL

A number of ICs were tested for JPL by BREL personnel. Most of these tests were not in situ. Complex LSI devices such as A/D converters, memories, and microprocessors were irradiated with the BREL Dynamitron or Cobalt-60 sources and tested on a Tektronix 3260 computerized IC tester by test programs written by BREL to JPL's specifications.

SECTION VI

DATA PRESENTATION

A. GRAPH NOMENCLATURE

The data are presented in this section, and a sample graph, explaining the nomenclature, is shown in Figure 2. Each of the electrical parameter data plots is represented by a single line per graph except for bipolar transistor data, which use multiple lines to represent different collector currents. A table at the bottom of each graph lists the test conditions when applicable, and the normal standard deviations of each data point at each dose level.*

Date codes usually indicate when the device was packaged. For example, 8420 indicates the device was packaged in the twentieth week of 1984. If no date code is available, the space may be used for other identifying numbers such as wafer number or lot number.

* The log-normal distribution actually provides a better fit to most radiation data than the normal distribution. Hence, caution should be exercised in estimating worst-case conditions based on the limited statistical data presented herein.

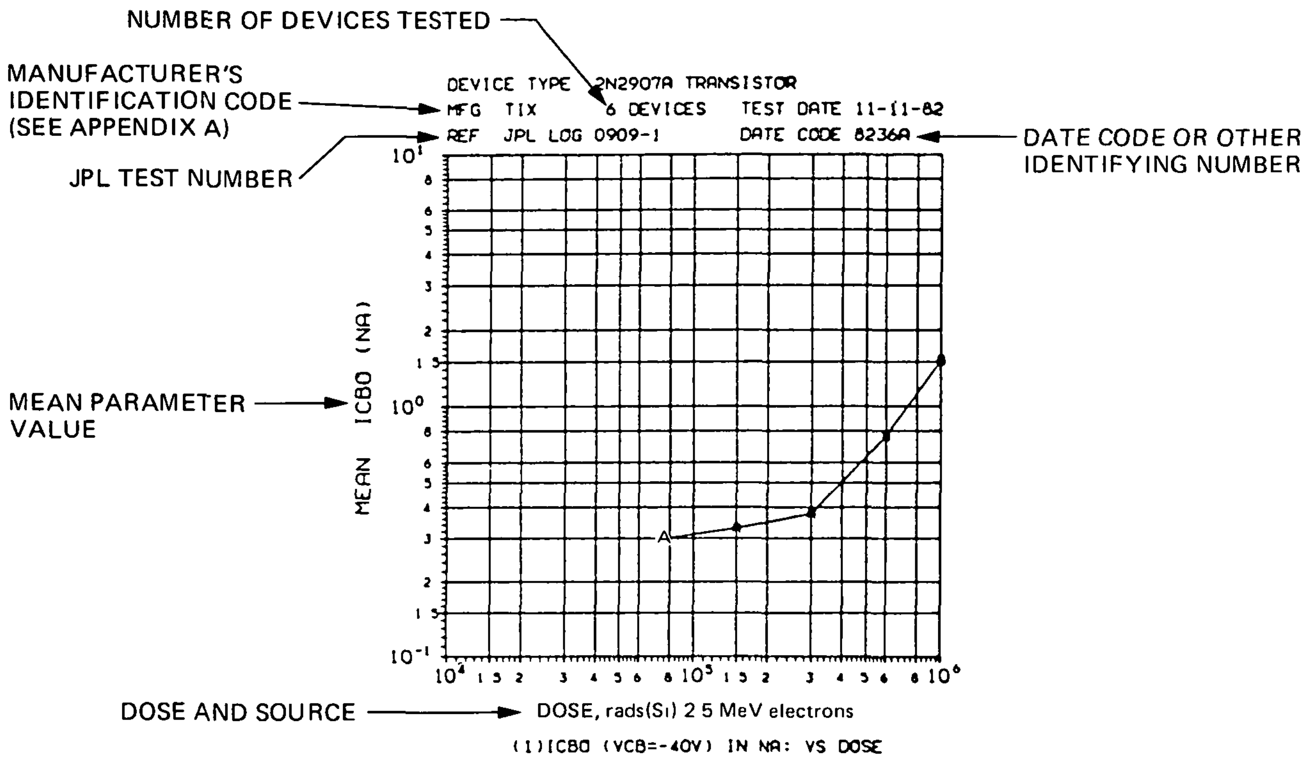


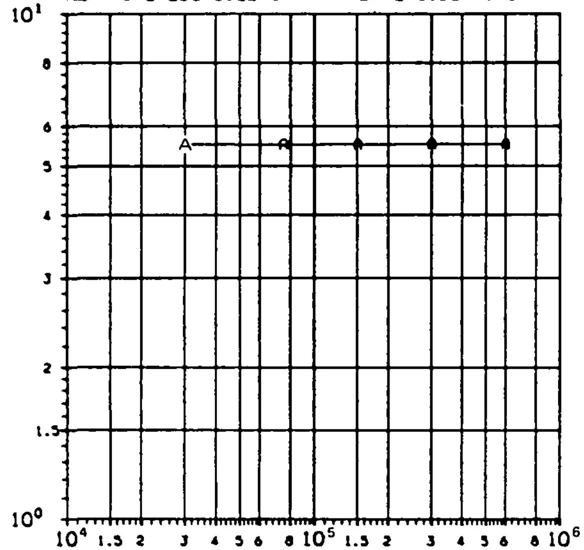
TABLE OF NORMAL STANDARD DEVIATIONS					
CURVE	DOSE, kilorads(Si)				
	75	150	300	600	1000
A	0797	1485	2411	6279	8553

Figure 2. Graph Format Description

B. DIODES

Diode radiation tests have been very limited for space programs because of the inherent radiation hardness at the total worst-case dose levels [300 krad(Si)]. Testing may be required for special high-precision applications or for higher total-dose environments where large (orders of magnitude) increases in the leakage current can be expected.

DEVICE TYPE: MZ4626 ZENER DIODE
MFG: MOT 5 DEVICES TEST DATE 6-22-82
REF: JPL LOG 0822-1 DATE CODE NONE

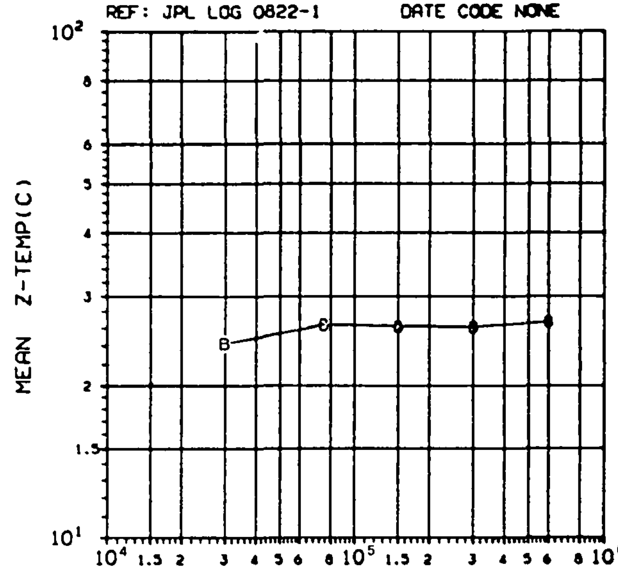


(1)VR-1 (IR=500UA) IN VOLTS: VS DOSE

TABLE OF NORMAL STANDARD DEVIATIONS					
CURVE	DOSE, kilorads(Si)				
	30	75	150	300	600
A	1342	1390	.1374	.1483	.1481

INITIAL MEAN VALUE VR-1(V) = $5.53 \times 10^{+0}$

DEVICE TYPE: MZ4626 ZENER DIODE
MFG: MOT 5 DEVICES TEST DATE 6-22-82
REF: JPL LOG 0822-1 DATE CODE NONE

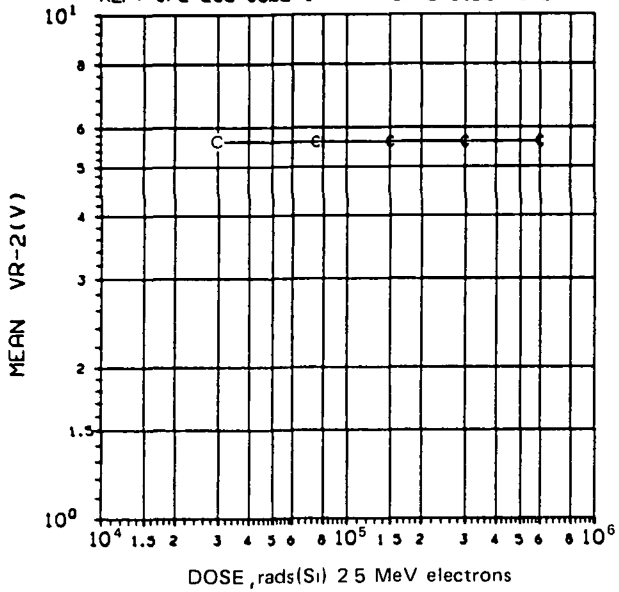


(2)ZENER TEMP (VR-1) IN DEG C: VS DOSE

TABLE OF NORMAL STANDARD DEVIATIONS					
CURVE	DOSE, kilorads(Si)				
	30	75	150	300	600
B	.7829	1.254	5030	4359	.5727

INITIAL MEAN VALUE Z-TEMP(C) = $2.37 \times 10^{+1}$

DEVICE TYPE: MZ4626 ZENER DIODE
MFG: MOT 5 DEVICES TEST DATE 6-22-82
REF: JPL LOG 0822-1 DATE CODE NONE

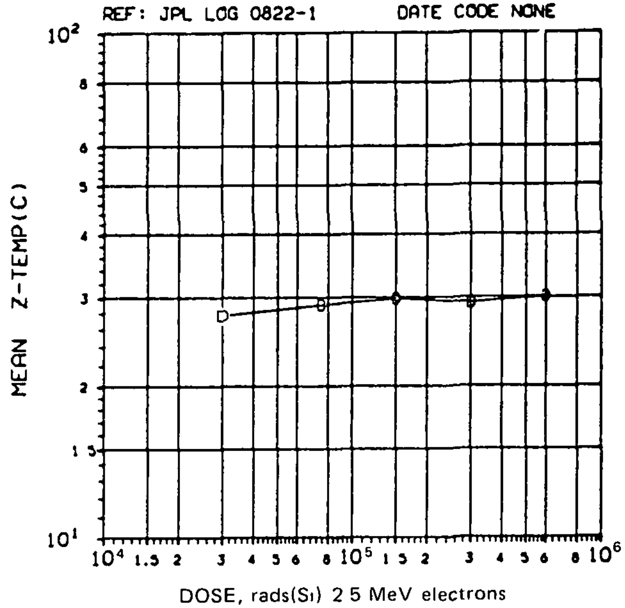


(3)VR-2 (IR=30MA) IN VOLTS: VS DOSE

TABLE OF NORMAL STANDARD DEVIATIONS					
CURVE	DOSE, kilorads(Si)				
	30	75	150	300	600
C	1642	1841	1803	1796	.1766

INITIAL MEAN VALUE VR-2(V) = 5.64X10^{+0}

DEVICE TYPE: MZ4626 ZENER DIODE
MFG: MOT 5 DEVICES TEST DATE 6-22-82
REF: JPL LOG 0822-1 DATE CODE NONE

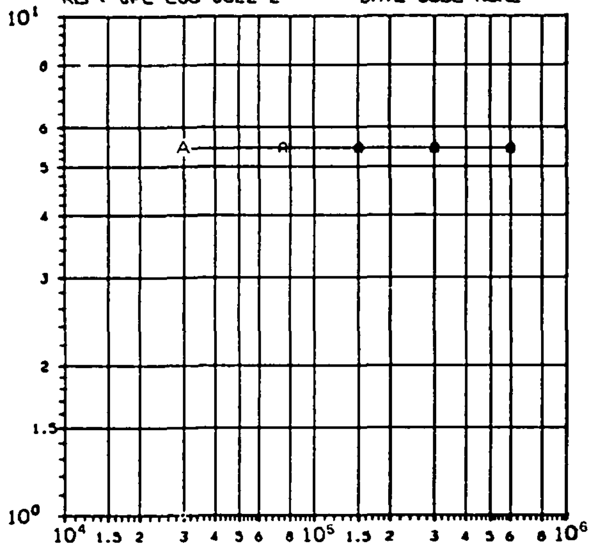


(4)ZENER TEMP (VR-1) IN DEG C: VS DOSE

TABLE OF NORMAL STANDARD DEVIATIONS					
CURVE	DOSE, kilorads(Si)				
	30	75	150	300	600
D	4970	1.276	6611	1 150	2864

INITIAL MEAN VALUE Z-TEMP(C) = 2.67X10^{+1}

DEVICE TYPE: MZ4626 ZENER DIODE
MFG: MOT 4 DEVICES TEST DATE 6-22-82
REF: JPL LOG 0822-2 DATE CODE NONE



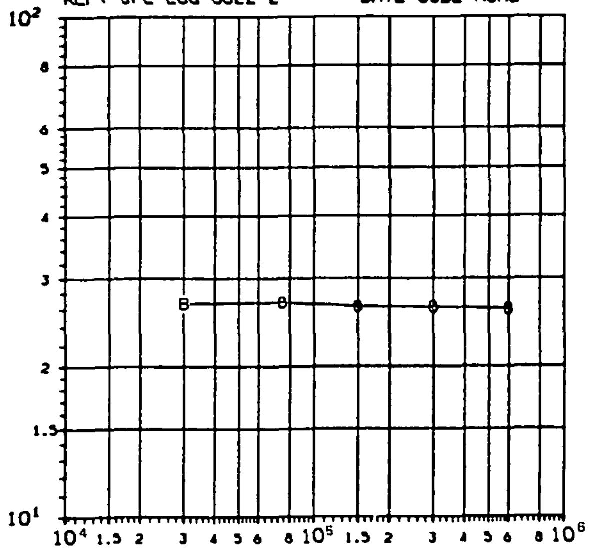
DOSE, rads(Si) 2 5 MeV electrons

(1)VR-1 (IR=500UA) IN VOLTS: VS DOSE

TABLE OF NORMAL STANDARD DEVIATIONS					
CURVE	DOSE, kilorads(Si)				
	30	75	150	300	600
A	.0356	.0356	.0337	.0350	.0370

INITIAL MEAN VALUE VR-1(V) = $5.44 \times 10^{+0}$

DEVICE TYPE: MZ4626 ZENER DIODE
MFG: MOT 4 DEVICES TEST DATE 6-22-82
REF. JPL LOG 0822-2 DATE CODE NONE



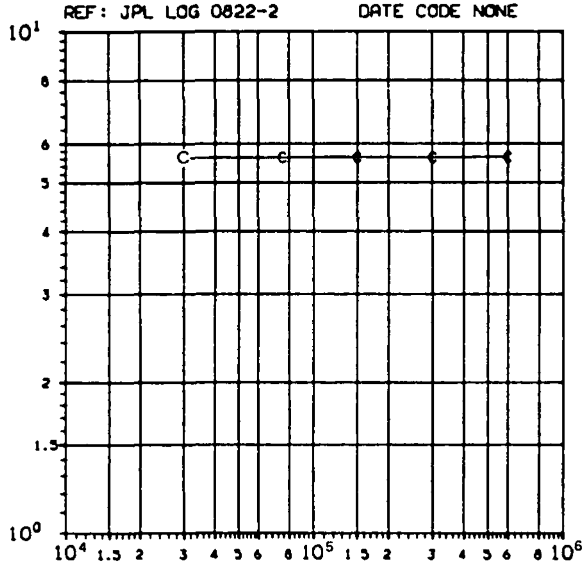
DOSE, rads(Si) 2.5 MeV electrons

(2)ZENER TEMP (VR-1) IN DEG C: VS DOSE

TABLE OF NORMAL STANDARD DEVIATIONS					
CURVE	DOSE, kilorads(Si)				
	30	75	150	300	600
B	2872	.2828	.3162	.5972	.6733

INITIAL MEAN VALUE Z-TEMP(C) = $2.71 \times 10^{+1}$

DEVICE TYPE: MZ4626 ZENER DIODE
MFG: MOT 4 DEVICES TEST DATE 6-22-82
REF: JPL LOG 0822-2 DATE CODE NONE



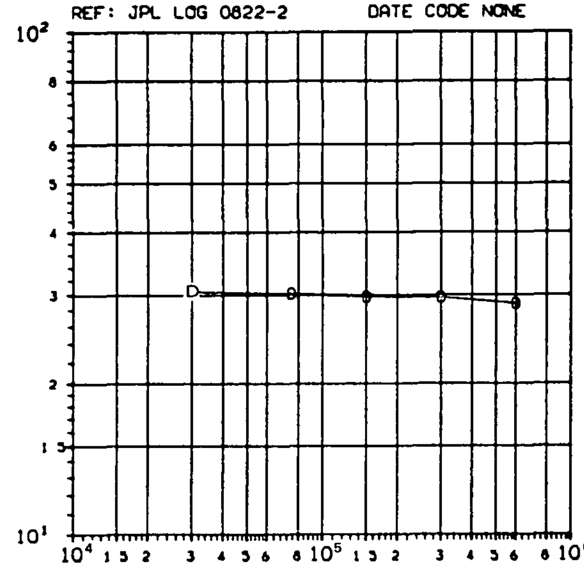
DOSE, rads(Si) 2 5 MeV electrons

(3)VR-2 (IR=30MA) IN VOLTS: VS DOSE

TABLE OF NORMAL STANDARD DEVIATIONS					
CURVE	DOSE, kilorads(Si)				
	30	75	150	300	600
C	.1506	1619	1507	1556	.1427

INITIAL MEAN VALUE VR-2(V) = 5 63X10^{+0}

DEVICE TYPE: MZ4626 ZENER DIODE
MFG: MOT 4 DEVICES TEST DATE 6-22-82
REF: JPL LOG 0822-2 DATE CODE NONE



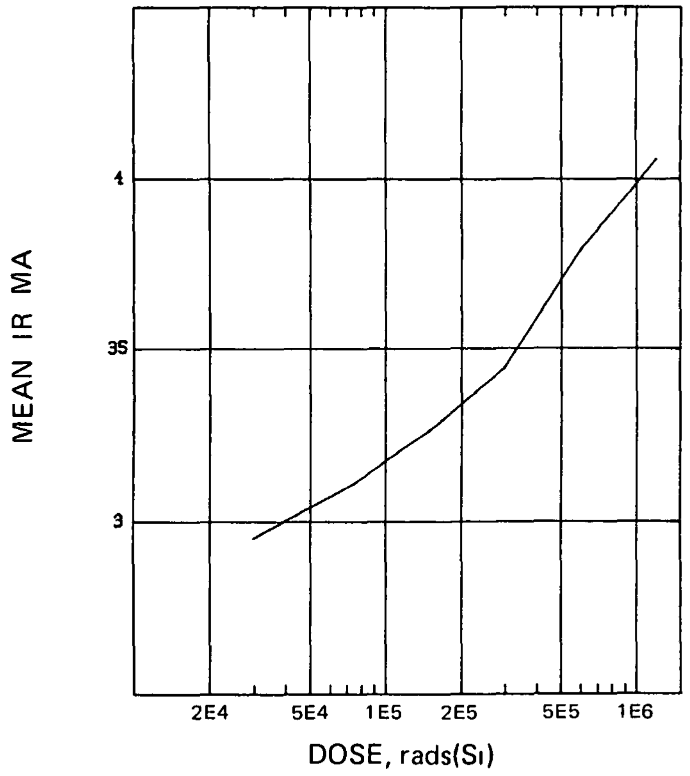
DOSE, rads(Si) 2 5 MeV electrons

(4)ZENER TEMP (VR-1) IN DEG C: VS DOSE

TABLE OF NORMAL STANDARD DEVIATIONS					
CURVE	DOSE, kilorads(Si)				
	30	75	150	300	600
D	.6351	5354	3500	4193	9535

INITIAL MEAN VALUE Z-TEMP(C) = 3.05X10^{+1}

DEVICE TYPE S02048 (SCHOTTKY DIODE)
MFG SCN 10DEVICE(S) TEST DATE 2-14-84 & 2-15-84
REF JPL LOG# 1042 DATE CODE NONE

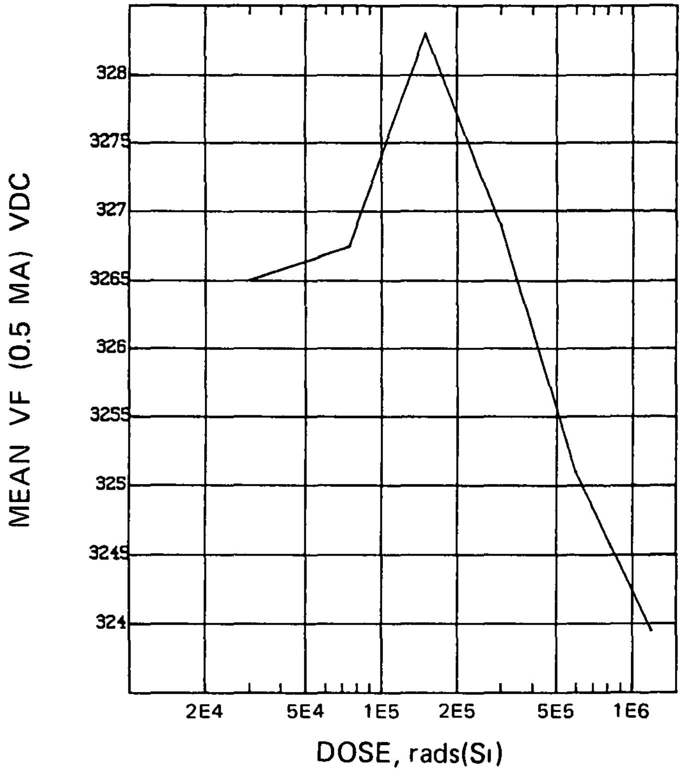


(1) IR MA vs DOSE

TABLE OF NORMAL STANDARD DEVIATIONS					
DOSE, rads(Si)					
3E4	7 5E4	1 5E5	3E5	6E5	1 2E6
2 7E-2	5 1E-2	6 6E-2	8 7E-2	1 3E-1	1 6E-1

INITIAL MEAN VALUE (IR MA) = 2 8E-1

DEVICE TYPE S02048 (SCHOTTKY DIODE)
MFG SCN 10DEVICE(S) TEST DATE 2-14-84 & 2-15-84
REF JPL LOG# 1042 DATE CODE NONE

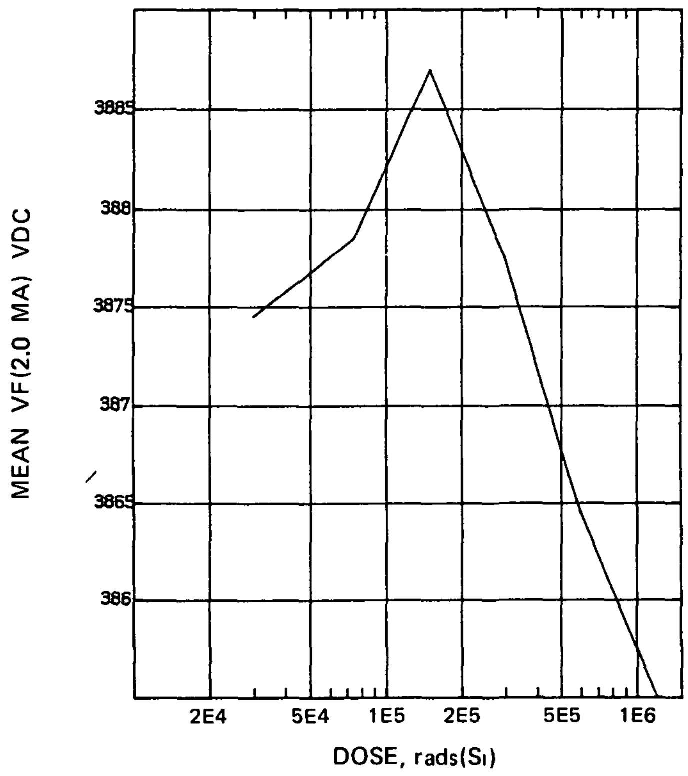


(2) VF(0 5 MA) VDC vs DOSE

TABLE OF NORMAL STANDARD DEVIATIONS					
DOSE, rads(Si)					
3E4	7 5E4	1 5E5	3E5	6E5	1 2E6
4 2E-3	4 6E-3	6E-3	4 5E-3	2 7E-3	2 2E-3

INITIAL MEAN VALUE VF(0 5 MA) VDC = 3 2E-1

DEVICE TYPE S02048 (SCHOTTKY DIODE)
MFG SCN 10DEVICE(S) TEST DATE 2-14-84 & 2-15-84
REF JPL LOG# 1042 DATE CODE NONE



(3) VF(2.0 MA) VDC vs DOSE

TABLE OF NORMAL STANDARD DEVIATIONS					
DOSE, rads(Si)					
3E4	7.5E4	1 5E5	3E5	6E5	1.2E6
3 2E-3	3 8E-3	4 5E-3	3 4E-3	2 1E-3	1 9E-3

INITIAL MEAN VALUE VF(2.0 MA) VDC = 3 8E-1

C. BIPOLAR TRANSISTORS

Transistor gain (h_{FE}) degradation is plotted as $\Delta(1/h_{FE}) = 1/h_{FE\phi} - 1/h_{FEo}$, where $h_{FE\phi}$ is the value at the specified radiation level, and h_{FEo} is the initial value. This subject was discussed in Section III, paragraph B.

A method of determining the final h_{FE}, when the initial h_{FE} and post-irradiation $\Delta(1/h_{FE})$ are known, is shown in the following example for a 2N2222 device type at V_{CE} of 20 V at 300 krad(Si).

1. Scale the value of $\Delta(1/h_{FE})$ from the applicable graph for a 2N2222 transistor at the stated conditions. In this example, $\Delta(1/h_{FE})$ is determined to be 0.008.

2. Determine the minimum specified pre-irradiation h_{FE} for this device type. In this example, the initial specified minimum h_{FE} is 100. Then proceed as follows:

$$h_{FE}(\text{final}) = \frac{1}{\Delta(1/h_{FE}) + \dfrac{1}{h_{FEo}(\text{initial})}}$$

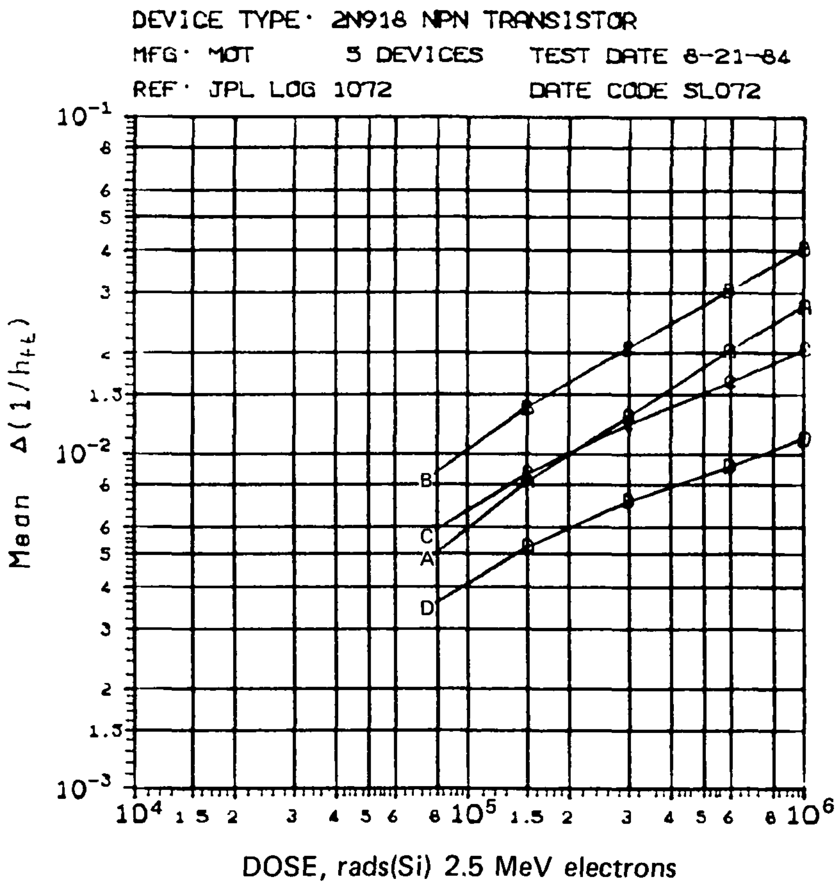
$$h_{FE}(\text{final}) = \frac{1}{0.008 + \dfrac{1}{100}} = 55.6$$

Table 6-1 may also be used to determine the final h_{FE}. Locate the post-irradiation $\Delta(1/h_{FE})$ value in the left-hand column, and the initial h_{FE} on the top row. The column and row intersection is the final h_{FE}.

The data on leakage and saturation currents are plotted directly as a function of dose.

Table 1. Determination of Final h_{FE}, Given Initial h_{FEo} and Post-Irradiation $\Delta(1/h_{FE})$

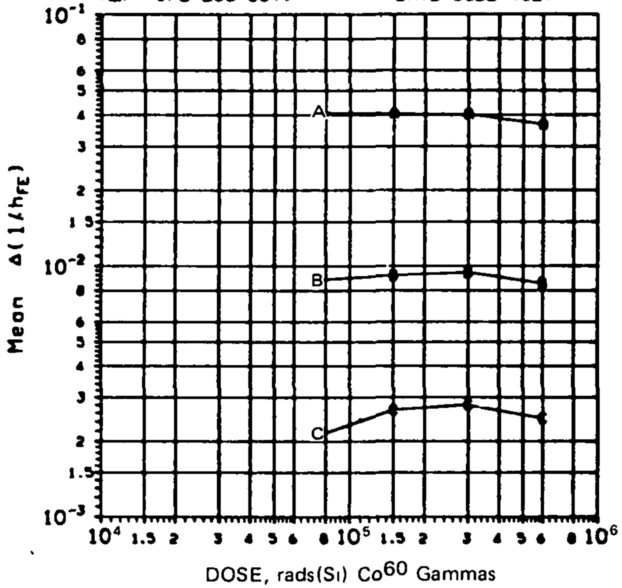
$\Delta(\frac{1}{h_{FE}})$	h_{FEo} 10	12	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100	110	120	130	140	150	170	200	250	300	350	400
0005	9.95	11.9	14.9	19.8	24.7	29.6	34.4	39.2	44.1	48.8	53.3	58.1	62.9	67.6	72.5	76.9	81.3	86.2	90.9	95.2	104	114	122	132	139	156	[illegible]	222	263	294	333
0007	9.93	11.9	14.9	19.7	24.6	29.4	34.1	38.9	43.7	48.3	52.9	57.5	61.7	66.7	71.4	75.8	80.0	84.8	89.3	93.5	102	111	119	128	135	152	175	212	250	278	313
001	9.90	11.9	14.8	19.6	24.4	29.2	33.8	38.5	43.1	47.6	52.1	56.6	61.0	65.4	69.9	74.1	78.1	82.6	87.0	90.9	99.0	107	115	124	130	145	167	200	233	256	286
.0015	9.85	11.8	14.7	19.4	24.1	28.7	33.2	37.7	42.2	46.5	51.8	55.0	59.2	63.4	67.6	71.4	75.2	79.4	83.3	87.0	94.3	102	109	116	122	135	154	182	208	227	250
002	9.80	11.7	14.6	19.2	23.8	28.3	32.7	37.0	41.3	45.5	49.5	53.6	57.5	61.4	65.4	69.0	72.5	76.3	80.0	83.3	90.1	96.8	103	110	115	127	143	167	189	204	222
0025	9.76	11.7	14.5	19.0	23.5	27.9	32.2	36.4	40.5	44.4	48.3	52.2	55.9	59.6	63.3	66.7	69.9	73.5	76.9	80.0	86.2	92.3	98.0	104	109	119	133	154	172	185	200
003	9.71	11.6	14.3	18.9	23.3	27.5	31.7	35.7	39.7	43.5	47.2	50.8	54.4	57.9	61.4	64.5	67.6	70.9	74.1	76.9	82.6	88.2	93.5	99.0	103	112	125	143	159	170	182
0035	9.66	11.5	14.3	18.7	23.0	27.2	31.2	35.1	38.9	42.6	46.1	49.5	52.9	56.2	59.5	62.5	65.4	68.5	71.4	74.1	79.4	84.8	89.3	94.3	98.0	106	118	133	147	156	167
004	9.62	11.5	14.1	18.5	22.7	26.8	30.7	34.5	38.2	41.7	45.1	48.4	51.6	54.7	57.8	60.6	63.3	66.2	69.0	71.4	76.3	81.1	85.5	90.1	93.8	101	111	125	137	115	154
005	9.52	11.3	13.9	18.2	22.2	26.1	29.9	33.3	36.8	40.0	43.1	46.2	49.0	51.9	54.6	57.1	59.5	62.1	64.5	66.7	70.9	75.0	78.7	82.6	85.7	91.7	100	111	121	127	133
006	9.43	11.2	13.8	17.9	21.7	25.4	28.9	32.3	35.5	38.5	41.3	44.1	46.7	49.3	51.8	54.1	56.2	58.5	60.6	62.5	66.2	69.8	73.0	76.3	79.0	84.0	90.9	100	108	112	118
007	9.35	11.1	13.6	17.5	21.3	24.8	28.1	31.3	34.3	37.0	39.7	42.3	44.6	47.0	49.3	51.3	53.2	55.2	57.1	58.8	62.1	65.2	68.0	70.9	73.2	77.5	83.3	90.0	97.1	101	105
008	9.26	11.0	13.4	17.2	20.8	24.2	27.4	30.3	33.1	35.7	38.2	40.5	42.7	44.9	47.0	48.8	50.5	52.4	54.1	55.6	58.5	61.2	63.7	66.2	68.2	71.9	76.9	83.3	88.5	91.7	95.2
009	9.17	10.8	13.2	16.9	20.4	23.6	26.6	29.4	32.1	34.5	36.8	39.0	41.0	42.9	44.8	46.5	48.1	49.8	51.3	52.6	55.3	57.7	60.0	62.1	63.8	67.1	71.4	76.9	81.3	84.0	87.0
010	9.09	10.7	13.0	16.7	20.0	23.1	26.0	28.6	31.1	33.3	35.5	37.5	39.4	41.2	42.9	44.4	45.9	47.4	48.8	50.0	52.4	54.5	56.5	58.5	60.0	62.9	66.7	71.4	75.2	77.5	80.0
011	9.01	10.6	12.9	16.4	19.6	22.6	25.3	27.7	30.1	32.3	34.3	36.1	37.4	39.5	41.1	42.6	43.4	45.3	46.5	47.6	49.7	51.2	53.5	55.3	56.5	59.2	62.5	66.7	69.9	71.9	74.1
.012	8.93	10.5	12.7	16.1	19.2	22.1	24.7	27.0	29.2	31.3	33.1	34.9	36.5	38.1	39.5	40.8	42.0	43.3	44.4	45.5	47.4	49.2	50.8	52.4	53.6	55.9	58.8	62.5	65.4	47.1	69.0
013	8.85	10.4	12.6	15.9	18.9	21.6	24.1	26.3	28.4	30.3	32.1	33.7	35.2	36.6	38.0	39.2	40.3	42.5	42.6	43.5	45.3	47.0	48.3	49.8	50.8	52.9	55.6	58.8	61.4	62.9	64.5
014	8.77	10.3	12.4	15.6	18.5	21.1	23.5	25.6	27.6	29.4	31.1	32.6	34.0	35.1	36.6	37.7	38.8	39.8	40.8	41.7	43.3	44.8	46.1	47.4	48.3	50.3	52.6	55.6	57.8	59.2	60.6
015	8.70	10.1	12.2	15.4	18.2	20.7	23.0	25.0	26.9	28.6	30.1	31.6	32.9	34.1	35.3	36.4	37.3	38.3	39.2	40.0	41.5	42.9	44.1	45.3	46.2	47.9	50.0	52.6	54.6	55.9	57.1
017	8.62	10.0	12.0	14.9	17.5	19.9	21.9	23.8	25.5	27.0	28.4	29.7	30.9	32.0	33.0	33.9	34.7	35.6	36.4	37.0	38.3	39.5	40.5	41.5	42.2	43.7	45.5	47.6	[illegible]	50.3	51.3
020	8.33	9.67	11.5	14.3	16.7	18.8	20.6	22.2	23.7	25.0	26.2	27.3	28.3	29.2	30.0	30.8	31.5	32.2	32.8	33.3	34.4	35.3	36.1	36.9	37.5	38.6	10.0	41.7	42.9	43.7	44.4
025	8.00	9.23	10.9	13.3	15.4	17.2	18.7	20.0	21.2	22.2	23.2	24.0	24.7	25.5	29.6	26.7	27.2	27.7	28.2	28.6	29.3	30.0	30.6	31.2	31.6	32.4	33.3	34.5	35.3	35.8	36.4
030	7.69	8.82	10.3	12.5	14.3	15.8	17.1	18.2	19.2	20.0	20.8	21.4	22.0	22.6	23.1	23.5	23.9	24.3	24.7	25.0	25.6	26.1	26.5	27.0	27.3	27.9	28.6	29.4	29.0	30.4	30.8
035	7.41	8.48	9.83	11.8	13.3	14.6	15.8	16.7	17.5	18.2	18.7	19.3	19.8	20.3	22.8	21.0	21.4	21.7	22.0	22.2	22.7	23.0	23.4	23.8	24.0	24.5	25.0	25.6	26.1	26.4	26.7
040	7.14	8.11	9.38	11.1	12.5	13.6	14.6	15.4	16.1	16.7	17.2	17.6	18.0	18.4	18.8	19.0	19.3	19.6	19.8	20.0	20.4	20.7	21.0	21.2	21.4	21.8	22.2	22.7	23.1	23.3	23.5
050	6.67	7.50	8.57	10.0	11.1	12.0	12.7	13.3	13.9	14.3	14.7	15.0	15.3	15.6	15.8	16.0	16.2	16.4	16.5	16.7	16.9	17.2	17.3	17.8	17.6	17.9	18.2	18.5	18.8	18.9	19.1
060	6.25	6.98	7.89	9.09	10.0	10.7	11.3	11.8	12.2	12.5	12.8	13.0	13.3	13.5	13.6	13.8	13.9	14.1	14.2	14.3	14.5	14.6	14.8	14.9	15.0	15.2	15.4	15.6	15.8	15.9	16.0
070	5.88	6.52	7.32	8.33	9.09	9.71	10.1	10.5	10.8	11.1	11.3	11.5	11.7	11.8	12.0	12.1	12.2	12.3	12.4	12.5	12.6	12.8	12.9	13.0	13.0	13.2	13.3	13.5	13.6	13.7	13.8
080	5.56	6.12	6.82	7.69	8.33	8.85	9.21	9.52	9 8	10.0	10.2	10.3	10.5	10.6	10.7	10.8	10.9	11.0	11.1	11.1	11.2	11.3	11.4	11.5	11.5	11.6	11.8	11.9	12.0	12.1	12.1
.090	5.26	5.77	6.38	7.14	7.69	8.13	8.42	8.70	8 9	9.09	9.25	9.38	9.49	9.59	9.68	9.76	9.68	9.89	9.95	10.0	10.1	10.2	10.2	10.3	10.3	10.4	10.5	10.6	10.7	10.8	10.8
.100	5.00	5.45	6.00	6.67	7.14	7.52	7.81	8.00	8 2	8.33	8.46	8.57	8.67	8.75	8.83	8.89	8.95	9.00	9.05	9.09	9.17	9.23	9.29	9.34	9.28	9.44	9.52	9.62	9.68	9.72	9.76



Δ(1/h_{FE}) VS DOSE

TABLE OF NORMAL STANDARD DEVIATIONS						
CURVE	I_c (uA)	V_{CE} (v)	DOSE, kilorads(Si) 75	150	300	600
A	10.00	5.00	.0012	.0012	.0015	.0013
B	10.00	5.00	.0007	.0012	.0017	0017
C	100.0	5.00	.0005	.0007	.0009	.0008
D	1000.	5.00	.0004	.0005	.0006	.0006

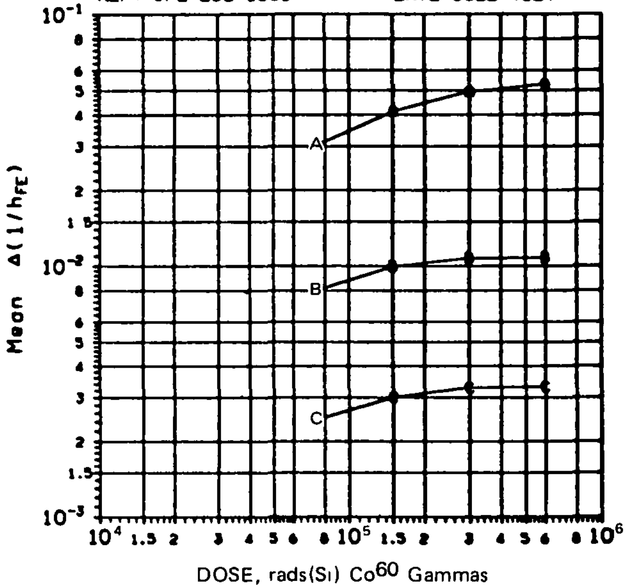
DEVICE TYPE: 2N1304 TRANSISTOR NPN
MFG: TIX 6 DEVICES TEST DATE 11-23-82
REF: JPL LOG 0879 DATE CODE 7827



$\Delta(1/h_{FE})$ VS DOSE

TABLE OF NORMAL STANDARD DEVIATIONS						
CURVE	I_C (mA)	V_{CE} (v)	DOSE, kilorads(Si) 75	150	300	600
A	.1000	10.0	.0341	.0341	.0290	.0260
B	1.000	10.0	.0048	.0049	.0052	.0050
C	10.00	10.0	.0025	.0027	.0028	.0027

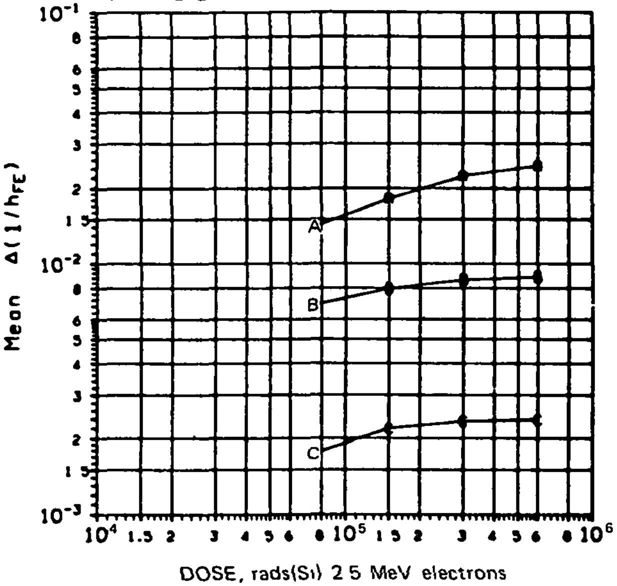
DEVICE TYPE: 2N1304 TRANSISTOR NPN
MFG: TIX 6 DEVICES TEST DATE 11-24-82
REF: JPL LOG 0880 DATE CODE 7827



$\Delta(1/h_{FE})$ VS DOSE

TABLE OF NORMAL STANDARD DEVIATIONS						
CURVE	I_C (mA)	V_{CE} (v)	DOSE, kilorads(Si) 75	150	300	600
A	.1000	10.0	.0550	.0639	.0735	.0777
B	1.000	10.0	.0101	.0118	.0131	.0134
C	10.00	10.0	.0031	.0037	.0041	.0042

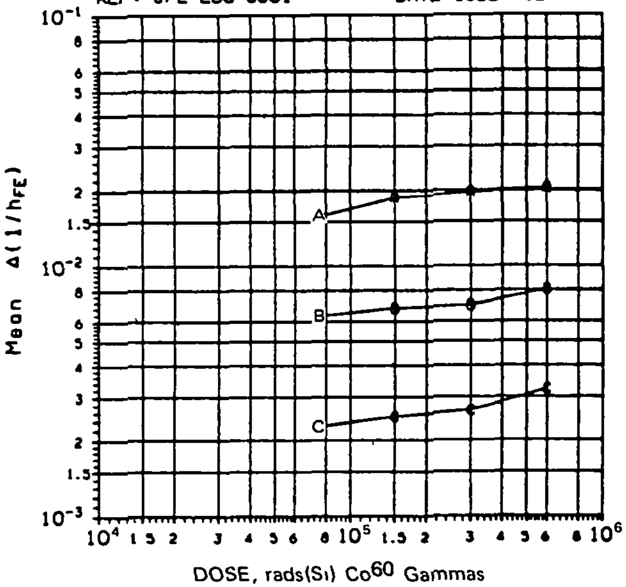
DEVICE TYPE. 2N1304 TRANSISTOR NPN
MFG: TIX 6 DEVICES TEST DATE 12-1-82
REF: JPL LOG 0876 DATE CODE 7827



Δ(1/h$_{FE}$) VS DOSE

TABLE OF NORMAL STANDARD DEVIATIONS						
CURVE	I_c (mA)	V_{CE} (v)	DOSE, kilorads(Si) 75	150	300	600
A	.1000	10.0	.0251	.0281	.0296	.0309
B	1.000	10.0	.0073	.0083	.0088	.0092
C	10.00	10.0	.0024	.0028	.0030	.0031

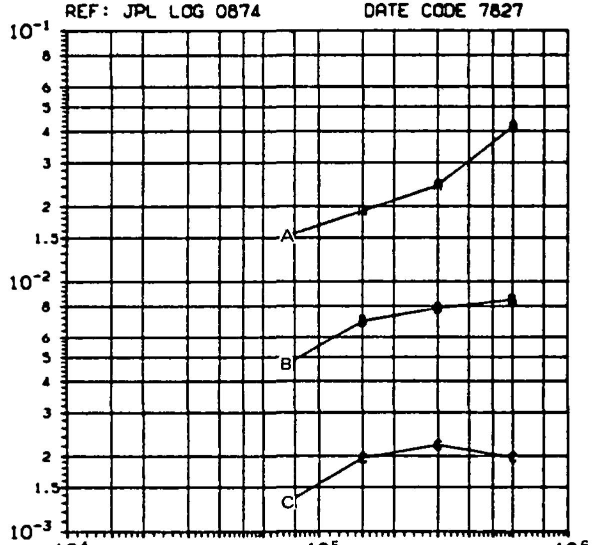
DEVICE TYPE: 2N1304 TRANSISTOR NPN
MFG: TIX 6 DEVICES TEST DATE 12-1-82
REF: JPL LOG 0881 DATE CODE 7827



Δ(1/h$_{FE}$) VS DOSE

TABLE OF NORMAL STANDARD DEVIATIONS						
CURVE	I_c (mA)	V_{CE} (v)	DOSE, kilorads(Si) 75	150	300	600
A	.1000	10.0	.0232	.0282	.0267	.0225
B	1.000	10.0	.0061	.0075	.0075	.0076
C	10.00	10.0	.0026	.0034	.0036	.0038

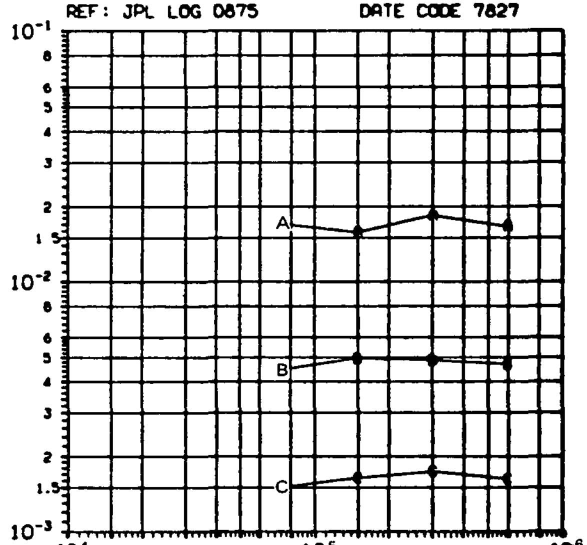
DEVICE TYPE: 2N1304 TRANSISTOR NPN
MFG. TIX 6 DEVICES TEST DATE 12-1-82
REF: JPL LOG 0874 DATE CODE 7827



$\Delta(1/h_{FE})$ VS DOSE

TABLE OF NORMAL STANDARD DEVIATIONS						
CURVE	I_C (mA)	V_{CE} (v)	DOSE, kilorads(Si) 75	150	300	600
A	1000	10.0	0094	.0200	.0249	.0608
B	1 000	10.0	0046	.0053	0058	.0067
C	10.00	10.0	0016	0020	0021	0019

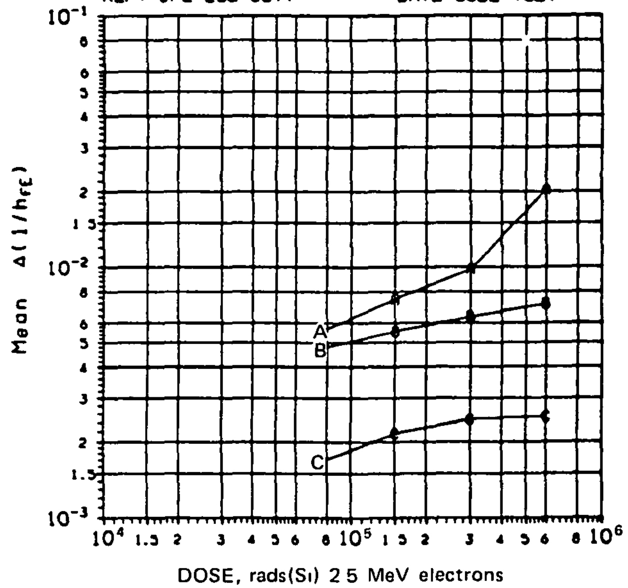
DEVICE TYPE: 2N1304 TRANSISTOR NPN
MFG. TIX 6 DEVICES TEST DATE 12-1-82
REF: JPL LOG 0875 DATE CODE 7827



$\Delta(1/h_{FE})$ VS DOSE

TABLE OF NORMAL STANDARD DEVIATIONS						
CURVE	I_C (mA)	V_{CE} (v)	DOSE, kilorads(Si) 75	150	300	600
A	.1000	10.0	.0294	.0270	.0304	.0214
B	1.000	10.0	.0029	.0029	.0031	.0027
C	10.00	10.0	.0008	.0008	.0008	.0006

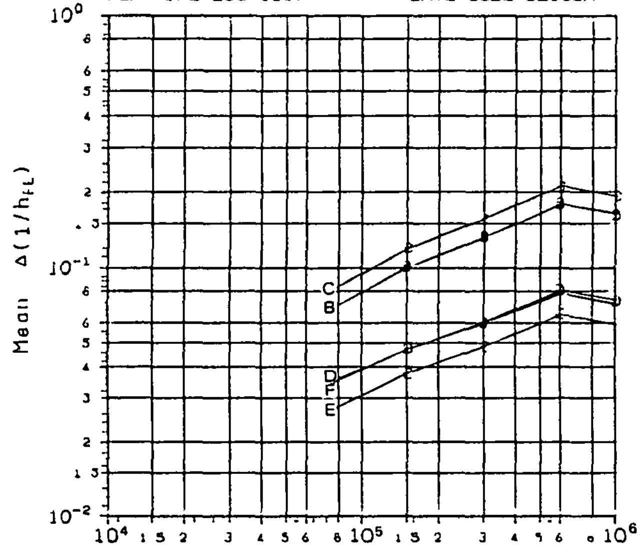
DEVICE TYPE: 2N1304 TRANSISTOR NPN
MFG. TIX 6 DEVICES TEST DATE 12-2-82
REF. JPL LOG 0877 DATE CODE 7827



$\Delta(1/h_{FE})$ VS DOSE

TABLE OF NORMAL STANDARD DEVIATIONS						
CURVE	I_c (mA)	V_{CE} (v)	DOSE, kilorads(Si) 75	150	300	600
A	1000	10 0	0108	0115	0122	0281
B	1.000	10 0	0033	0034	0038	0055
C	10 00	10.0	0013	0014	0018	0021

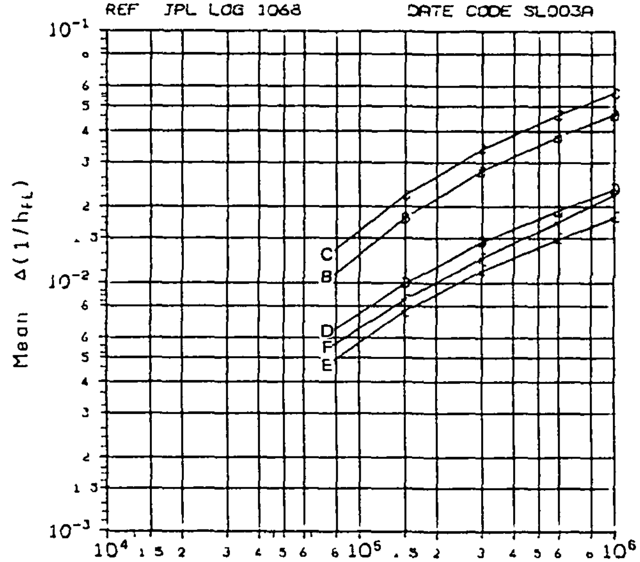
DEVICE TYPE 2N2222 NPN TRANSISTOR
MFG MOT 5 DEVICES TEST DATE 8-16-84
REF JPL LOG 1069 DATE CODE SL103A



Δ(1/hFE) VS DOSE

TABLE OF NORMAL STANDARD DEVIATIONS						
CURVE	I_C (mA)	V_{CE} (v)	DOSE, kilorads(Si) 75	150	300	600
B	1000	20 0	0036	0041	0060	0048
C	1000	500	0044	0046	0069	0053
D	1 000	500	0015	0016	0025	0019
E	1 000	20 0	0013	0013	0020	0015
F	20 00	20 0	0014	0019	0023	0021

DEVICE TYPE 2N2222 NPN TRANSISTOR
MFG MOT 5 DEVICES TEST DATE 8-16-84
REF JPL LOG 1068 DATE CODE SL003A



Δ(1/hFE) VS DOSE

TABLE OF NORMAL STANDARD DEVIATIONS						
CURVE	I_C (mA)	V_{CE} (v)	DOSE, kilorads(Si) 75	150	300	600
B	1000	20 0	0047	0063	0076	0069
C	1000	500	0054	0074	0089	0103
D	1 000	500	0019	0025	0032	0037
E	1 000	20 0	0015	0021	0025	0030
F	20 00	20 0	0013	0017	0025	0033

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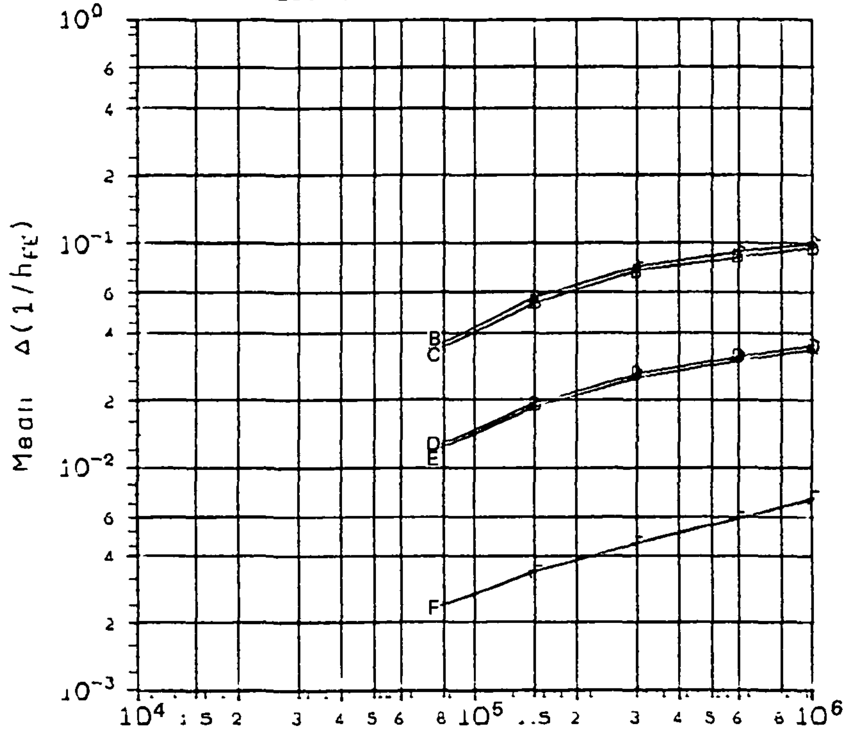
DEVICE TYPE: 2N2222 NPN TRANSISTOR

MFG: RAY 3 DEVICES TEST DATE 1-16-85

REF: JPL LOG 1116 DATE CODE 8305

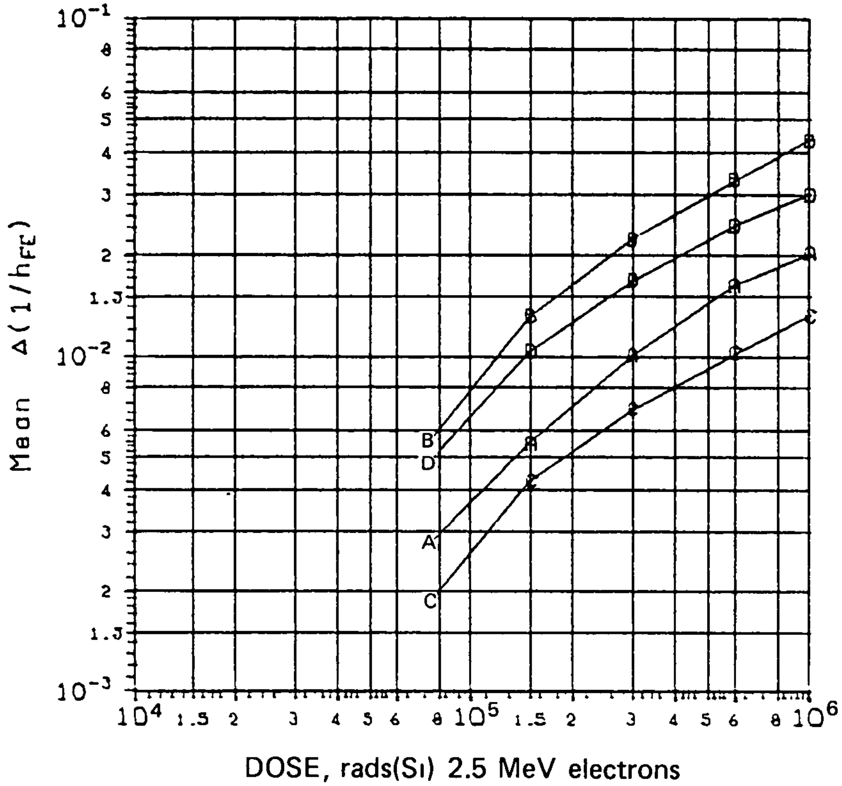


DOSE, rads(Si) 2.5 MeV electrons

$\Delta(1/h_{FE})$ VS DOSE

TABLE OF NORMAL STANDARD DEVIATIONS						
CURVE	I_C (mA)	V_{CE} (v)	DOSE, kilorads(Si) 75	150	300	600
B	.1000	20 0	.0083	.0059	.0046	.0042
C	.1000	500	0087	.0062	0049	.0044
D	1 000	500	.0027	.0022	0020	0019
E	1.000	20.0	0026	.0021	0019	0019
F	20.00	20.0	.0004	.0004	.0004	.0004

DEVICE TYPE: 2N2369 NPN TRANSISTOR
MFG: MOT 5 DEVICES TEST DATE 8-20-84
REF: JPL LOG 1073 DATE CODE SL073

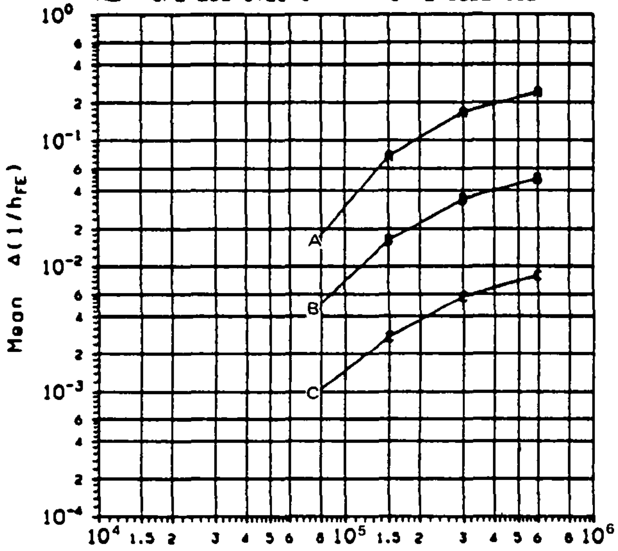


$\Delta(1/h_{FE})$ VS DOSE

TABLE OF NORMAL STANDARD DEVIATIONS

CURVE	I_c (mA)	V_{CE} (v)	DOSE, kilorads(Si) 75	150	300	600
A	2.000	10.0	.0012	.0026	.0042	.0047
B	2.000	10.0	.0034	.0066	.0099	.0126
C	10.00	400	.0011	.0022	.0032	.0039
D	55.00	.400	.0022	.0039	.0062	.0078

DEVICE TYPE: 2N2432 NPN LOW POWER TRANSISTO
MFG: TIX 8 DEVICES TEST DATE 3-31-81
REF: JPL LOG 0725-1 DATE CODE 102

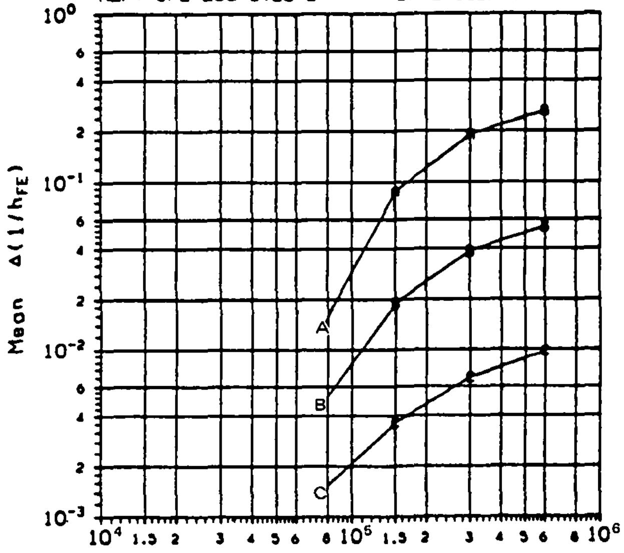


DOSE, rads(Si) 2 5 MeV electrons

$\Delta(1/h_{FE})$ VS DOSE

TABLE OF NORMAL STANDARD DEVIATIONS						
CURVE	I_C (mA)	V_{CE} (v)	DOSE, kilorads(Si) 75	150	300	600
A	.1000	10.0	.0185	0637	.0826	.0852
B	1.000	10 0	.0045	0121	.0151	.0155
C	10.00	10.0	.0012	0020	.0024	0028

DEVICE TYPE: 2N2432 NPN LOW POWER TRANSISTO
MFG: TIX 8 DEVICES TEST DATE 3-31-81
REF. JPL LOG 0725-2 DATE CODE 102

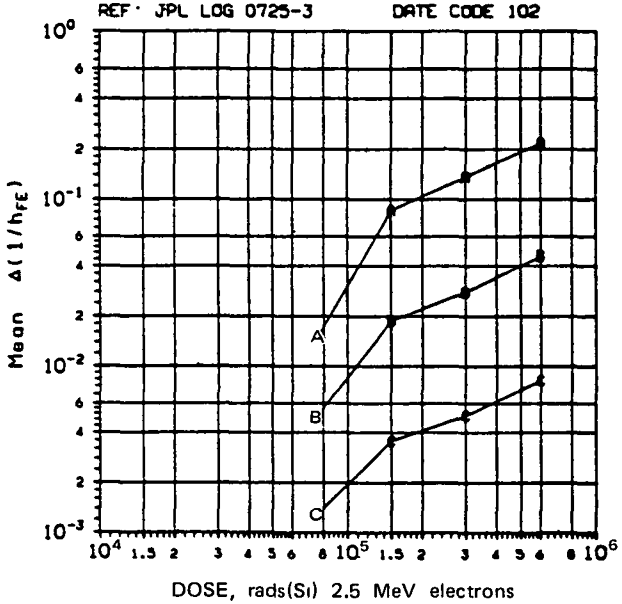


DOSE, rads(Si) 2 5 MeV electrons

$\Delta(1/h_{FE})$ VS DOSE

TABLE OF NORMAL STANDARD DEVIATIONS						
CURVE	I_C (mA)	V_{CE} (v)	DOSE, kilorads(Si) 75	150	300	600
A	.1000	10.0	0084	.0598	.1065	.1429
B	1.000	10.0	.0027	.0109	.0167	.0219
C	10.00	10.0	.0007	.0017	0023	.0031

DEVICE TYPE: 2N2432 NPN LOW POWER TRANSISTO
MFG: TIX 8 DEVICES TEST DATE 3-31-81
REF · JPL LOG 0725-3 DATE CODE 102



$\Delta(1/h_{FE})$ VS DOSE

TABLE OF NORMAL STANDARD DEVIATIONS						
CURVE	I_C (mA)	V_{CE} (v)	DOSE, kilorads(Si) 75	150	300	600
A	.1000	10.0	0076	.0373	.0598	.0819
B	1.000	10.0	.0022	.0078	.0112	.0150
C	10.00	10.0	0006	.0013	.0018	.0024

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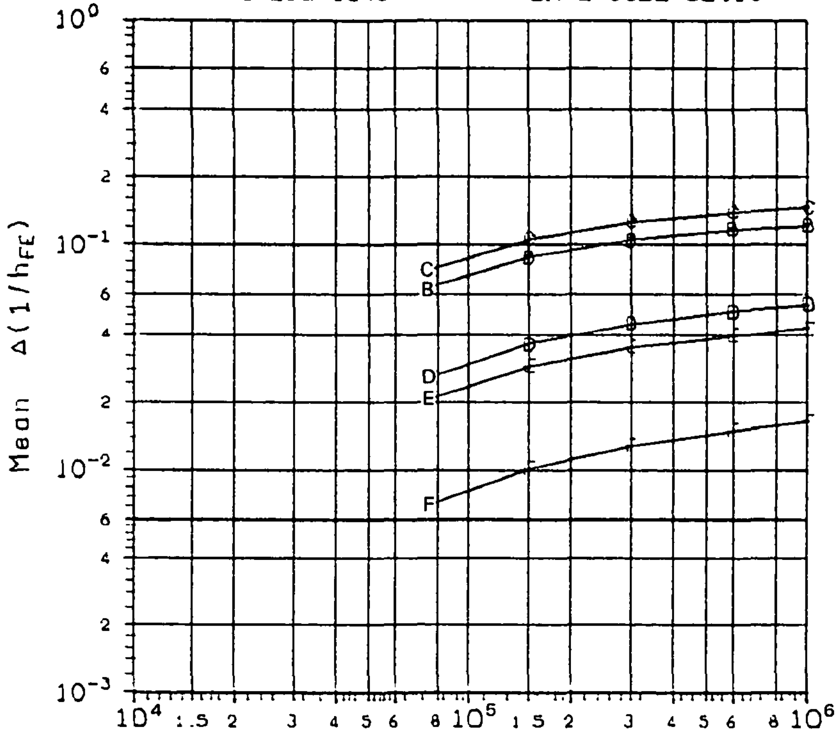
DEVICE TYPE: 2N2484 NPN TRANSISTOR
MFG: MOT   5 DEVICES   TEST DATE 8-17-84
REF: JPL LOG 1075   DATE CODE SL418



DOSE, rads(Si) 2.5 MeV electrons

$\Delta(1/h_{FE})$ VS DOSE

TABLE OF NORMAL STANDARD DEVIATIONS						
CURVE	I_c (mA)	V_{CE} (v)	DOSE, kilorads(Si) 75	150	300	600
B	1000	20 0	0118	0114	.0101	0115
C	1000	500	0140	0144	0134	0136
D	1 000	500	0053	0054	0052	0050
E	1 000	20 0	0041	0041	0041	0039
F	10 00	20 0	0015	0017	0017	0015

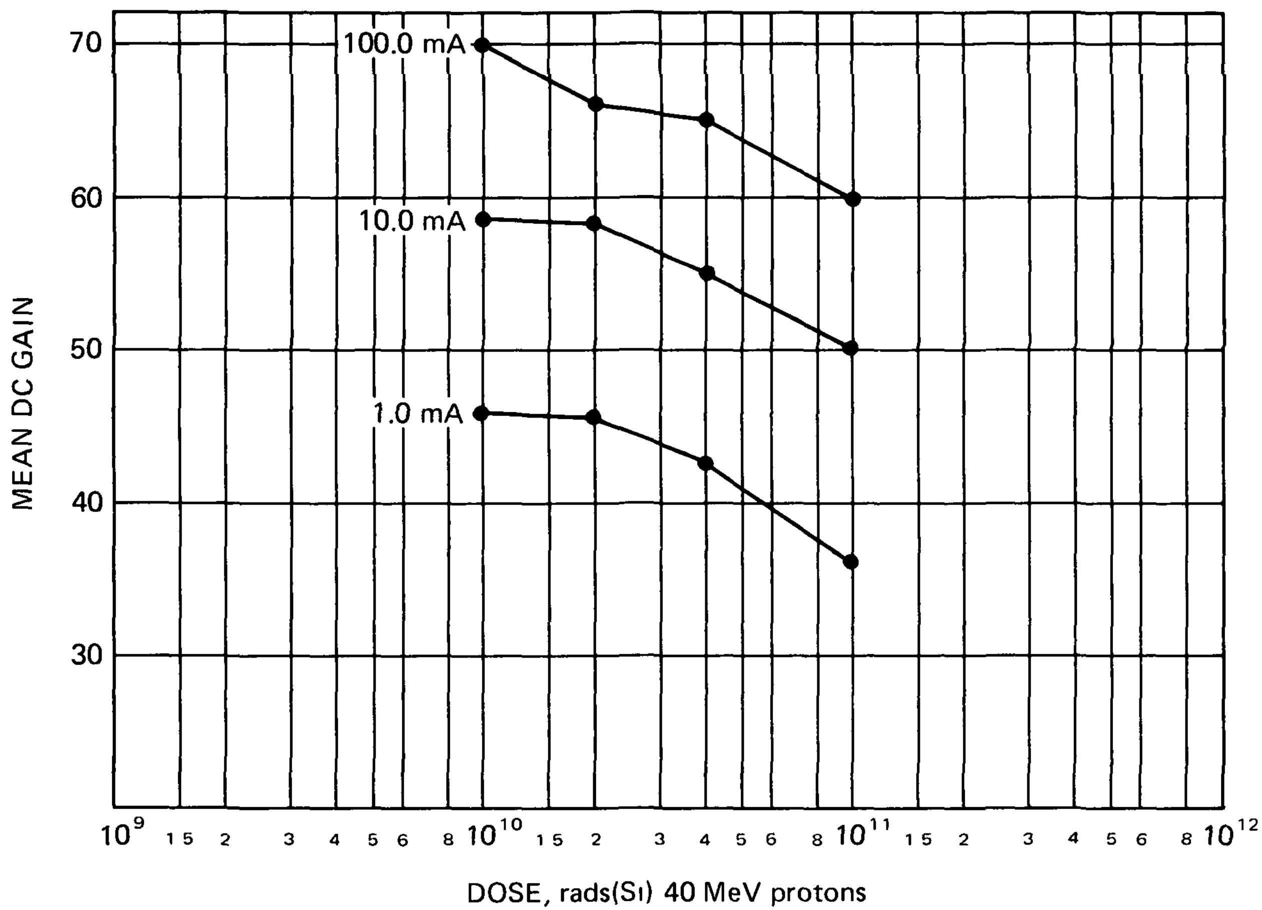
DEVICE TYPE. 2N2658 NPN POWER TRANSISTOR

MFG: SOD 6 DEVICES

REF· JPL LOG 0760

TEST DATE: 7/16/81

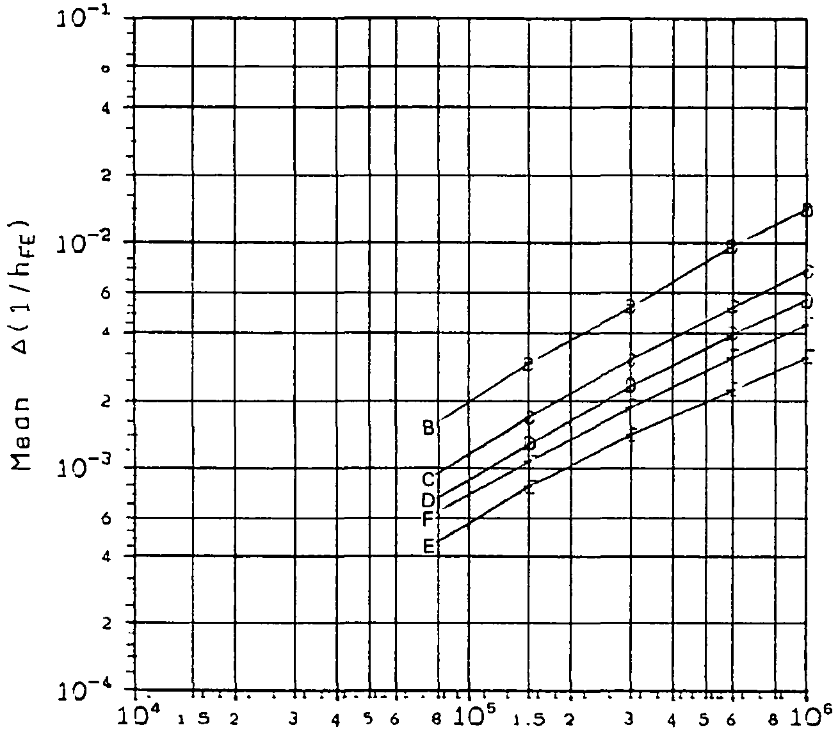
DATE CODE NONE



DC GAIN vs DOSE

INITIAL MEAN DC GAIN VALUE = 46.5 @ 1.0 mA
60.2 @ 10.0 mA
71 7 @ 100 0 mA

DEVICE TYPE: 2N2907 PNP TRANSISTOR
MFG: MOT 5 DEVICES TEST DATE 2-7-85
REF. JPL LOG 1074 DATE CODE SL333



DOSE, rads(Si) 2.5 MeV electrons

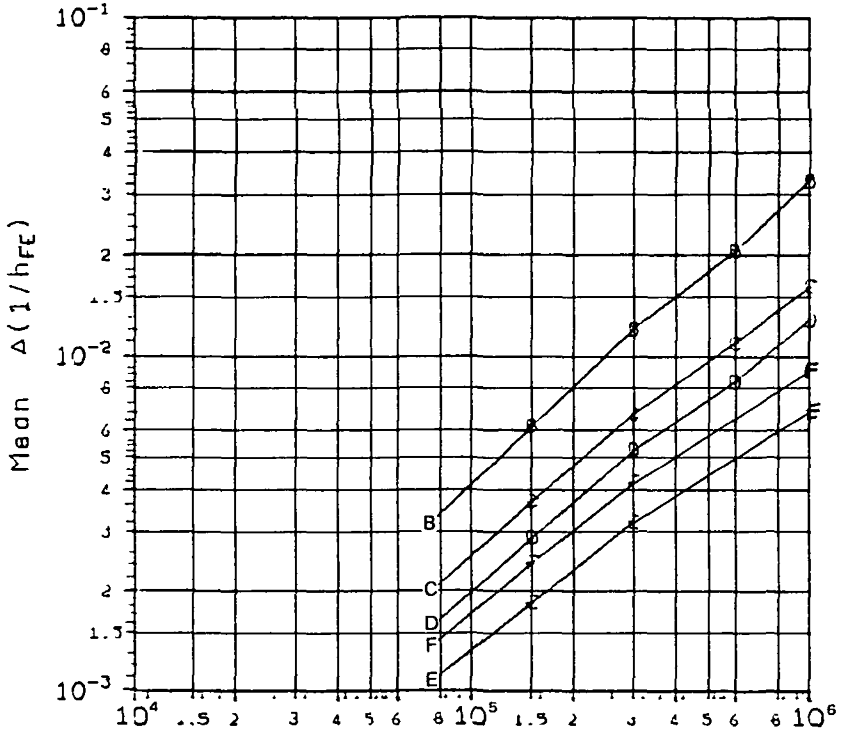
$\Delta(1/h_{FE})$ VS DOSE

TABLE OF NORMAL STANDARD DEVIATIONS						
CURVE	I_C (mA)	V_{CE} (v)	DOSE, kilorads(Si) 75	150	300	600
B	1000	500	.0001	0002	.0005	0002
C	1 000	500	.0000	0000	0002	.0001
D	1 000	20 0	.0000	.0000	.0001	.0001
E	10 00	20 0	0000	.0000	0000	0001
F	10.00	500	0000	.0000	0001	0001

DEVICE TYPE: 2N2907 PNP TRANSISTOR

MFG: RAY 3 DEVICES TEST DATE 2-7-85

REF: JPL LOG 1117 DATE CODE 8318

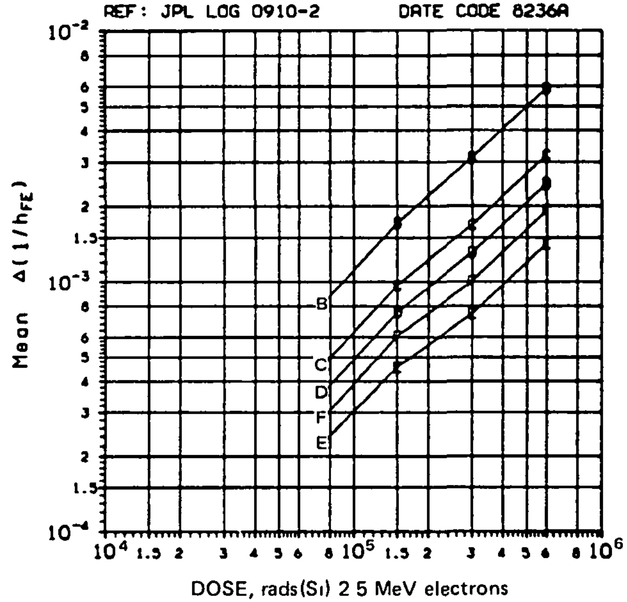


DOSE, rads(Si) 2.5 MeV electrons

$\Delta(1/h_{FE})$ VS DOSE

TABLE OF NORMAL STANDARD DEVIATIONS						
CURVE	I_c (mA)	V_{CE} (v)	DOSE, kilorads(Si) 75	150	300	600
B	.1000	.500	.0008	.0012	.0032	.0033
C	1.000	.500	.0004	.0006	.0014	.0014
D	1.000	20.0	.0004	.0006	.0012	.0014
E	10.00	20.0	.0002	.0003	****	.0001
F	10.00	.500	.0002	.0003	****	.0007

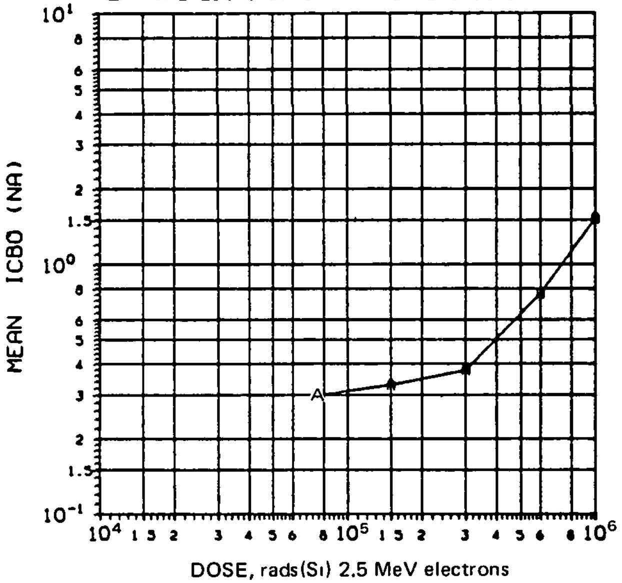
DEVICE TYPE: 2N2907 TRANSISTOR
MFG: TIX 6 DEVICES TEST DATE 11-17-82
REF: JPL LOG 0910-2 DATE CODE 8236A



$\Delta(1/h_{FE})$ VS DOSE

TABLE OF NORMAL STANDARD DEVIATIONS						
CURVE	I_c (mA)	V_{CE} (v)	DOSE, kilorads(Si) 75	150	300	600
B	1000	500	.0003	0005	.0009	0015
C	1.000	.500	.0001	.0002	0004	.0007
D	1.000	20.0	0001	0002	0003	.0006
E	10.00	20.0	.0001	.0001	.0002	.0003
F	10.00	20 0	.0001	.0001	.0002	.0003

DEVICE TYPE· 2N2907 TRANSISTOR
MFG: TIX 6 DEVICES TEST DATE 11-11-82
REF. JPL LOG 0909-1 DATE CODE 8236A

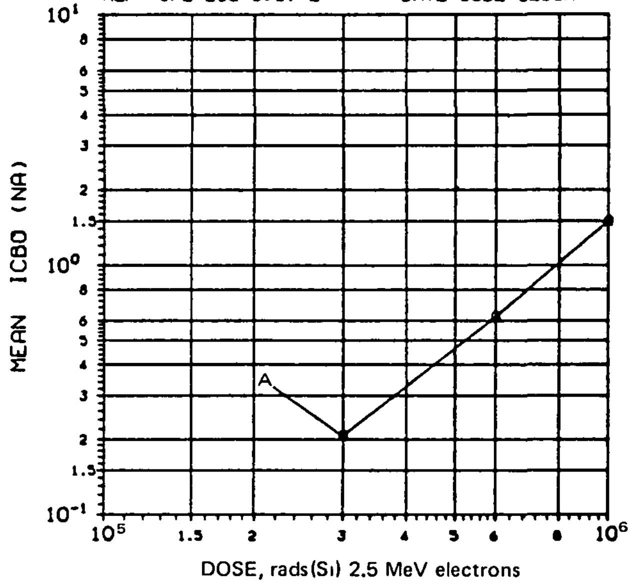


(1)ICBO (VCB=-40V) IN NA: VS DOSE

TABLE OF NORMAL STANDARD DEVIATIONS					
CURVE	DOSE, kilorads(Si)				
	75	150	300	600	1000
A	.0797	.1485	.2411	.6279	8553

INITIAL MEAN VALUE ICBO (NA) = 1.18×10^{-1}

DEVICE TYPE: 2N2907 TRANSISTOR
MFG: TIX 6 DEVICES TEST DATE 11-11-82
REF: JPL LOG 0909-2 DATE CODE 8236A

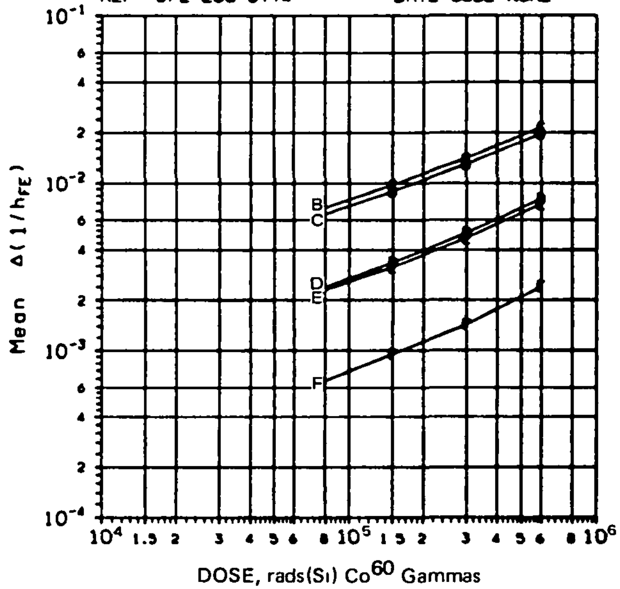


(1)ICBO (VCB=-40V) IN NA: VS DOSE

TABLE OF NORMAL STANDARD DEVIATIONS				
CURVE	DOSE, kilorads(Si)			
	210	300	600	1000
A	.0714	.0476	.1615	.7820

INITIAL MEAN VALUE ICBO (NA) = 2.19×10^{-1}

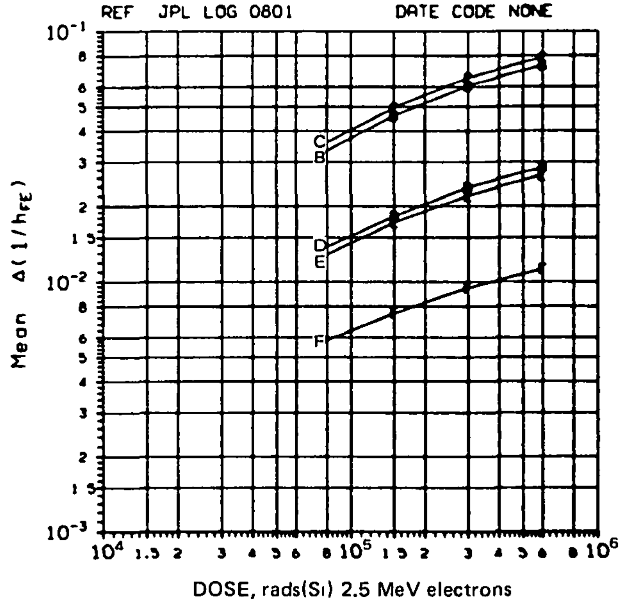
DEVICE TYPE· 2N2920 DUAL NPN TRANSISTOR
MFG MOT 7 DEVICES TEST DATE 7-14-81
REF· JPL LOG 0774 DATE CODE NONE



$\Delta(1/h_{FE})$ VS DOSE

TABLE OF NORMAL STANDARD DEVIATIONS						
CURVE	I_C (mA)	V_{CE} (v)	DOSE, kilorads(Si) 75	150	300	600
B	1000	20.0	.0009	.0015	.0020	.0029
C	.1000	500	.0010	.0017	.0022	.0031
D	1.000	.500	0003	.0006	.0008	.0011
E	1.000	20.0	.0003	.0005	.0007	.0011
F	10 00	20.0	.0002	0002	.0003	.0004

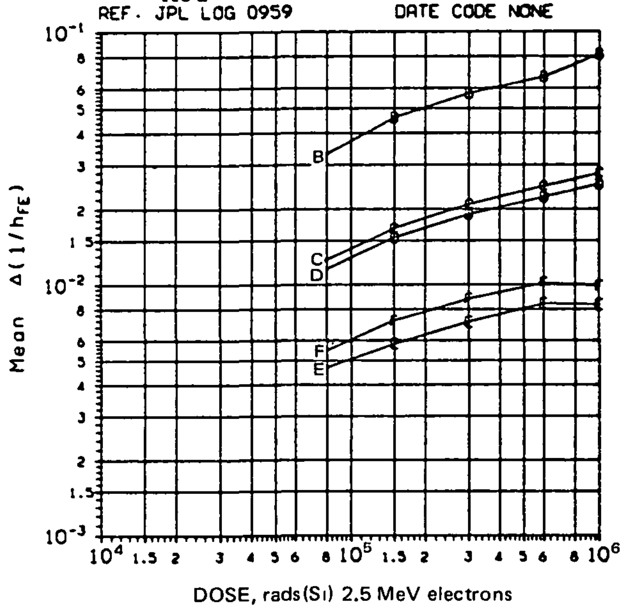
DEVICE TYPE 2N2920 DUAL NPN TRANSISTOR
MFG MOT 6 DEVICES TEST DATE 2-05-82
REF JPL LOG 0801 DATE CODE NONE



$\Delta(1/h_{FE})$ VS DOSE

TABLE OF NORMAL STANDARD DEVIATIONS						
CURVE	I_C (mA)	V_{CE} (v)	DOSE, kilorads(Si) 75	150	300	600
B	1000	20 0	0007	.0011	.0009	.0015
C	1000	5.00	0008	0012	.0009	.0016
D	1 000	500	0002	0004	0003	0006
E	1 000	20 0	0002	.0003	.0002	0004
F	10 00	20 0	0004	0005	0005	0004

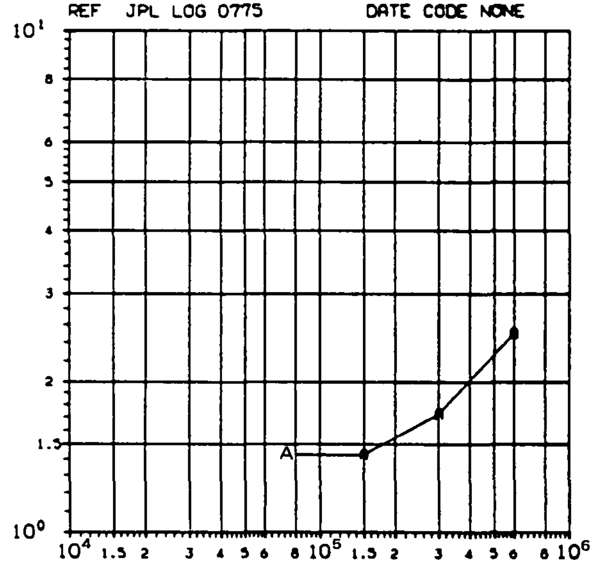
DEVICE TYPE 2N2920 TRANSISTOR DUAL NPN
MFG. MOT 6 DEVICES TEST DATE 1-06-83
REF. JPL LOG 0959 DATE CODE NONE



$\Delta(1/h_{FE})$ VS DOSE

TABLE OF NORMAL STANDARD DEVIATIONS						
CURVE	I_C (mA)	V_{CE} (v)	DOSE, kilorads(Si) 75	150	300	600
B	1000	500	0028	0033	0044	0034
C	1.000	.500	0010	0006	.0009	0010
D	1.000	20 0	0007	0006	0008	0007
E	10 00	20.0	0003	.0005	0000	0024
F	10.00	500	0003	.0004	0003	0023

DEVICE TYPE 2N2920 DUAL NPN TRANSISTOR
MFG MOT 8 DEVICES TEST DATE 7-10-81
REF JPL LOG 0775 DATE CODE NONE



DOSE, rads(Si) Co^{60} Gammas

(1)ICBO IN NA (VCE=30V). VS DOSE

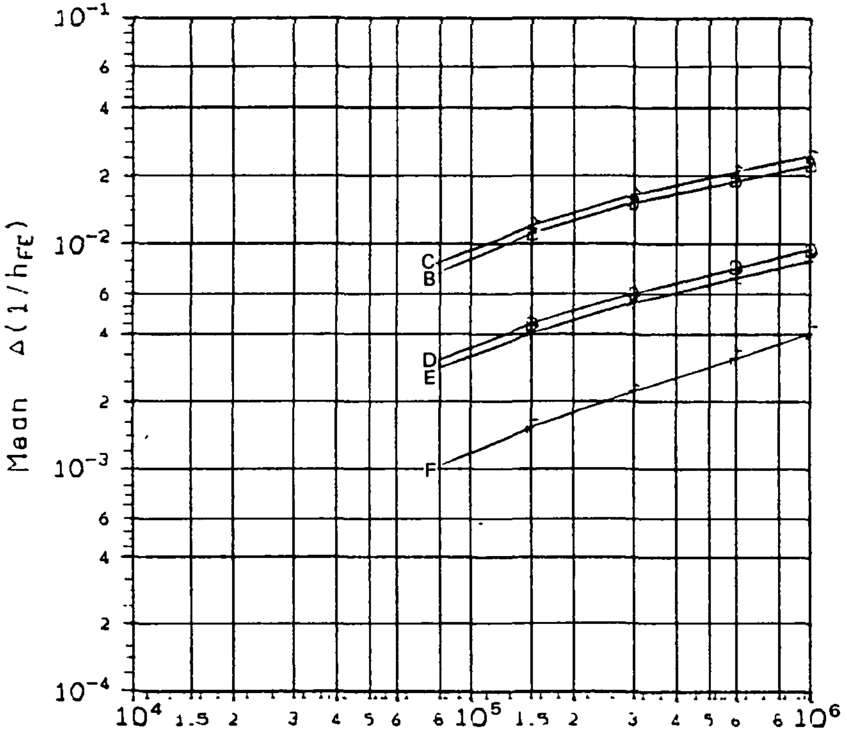
TABLE OF NORMAL STANDARD DEVIATIONS				
CURVE	DOSE, kilorads(Si)			
	75	150	300	600
A	1 293	1.054	1 025	1.069

INITIAL MEAN VALUE ICBO (NA) = $3.29\times10^{+0}$

DEVICE TYPE · 2N2920 NPN TRANSISTOR DUAL

MFG: RAY   6 DEVICES   TEST DATE 2-8-85

REF: JPL LOG 1115   DATE CODE 8205



DOSE, rads(Si) 2.5 MeV electrons

$\Delta(1/h_{FE})$ VS DOSE

TABLE OF NORMAL STANDARD DEVIATIONS						
CURVE	I_C (mA)	V_{CE} (v)	DOSE, kilorads(Si) 75	150	300	600
B	.1000	20.0	.0007	.0007	.0008	.0007
C	.1000	500	.0007	.0007	.0008	.0007
D	1.000	500	.0002	.0002	.0003	.0003
E	1.000	20.0	.0002	.0002	.0003	.0003
F	10.00	20.0	.0001	.0001	.0001	.0002

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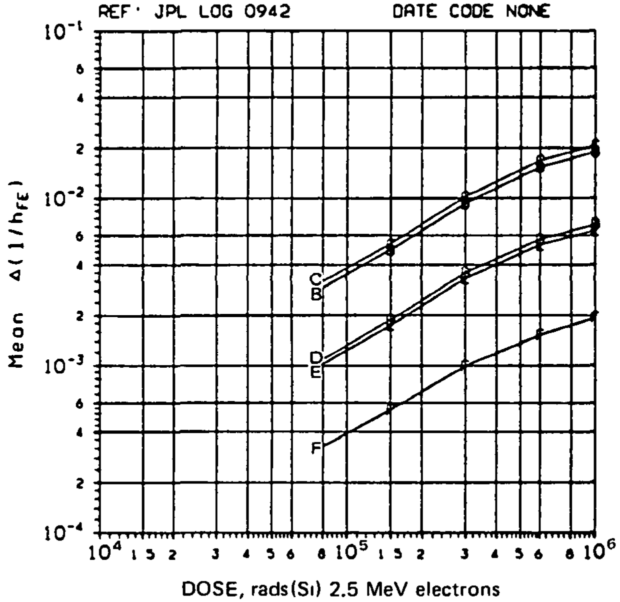
DEVICE TYPE 2N2920 TRANSISTOR DUAL NPN
MFG TIX 3 DEVICES TEST DATE 1-3-82
REF· JPL LOG 0942 DATE CODE NONE

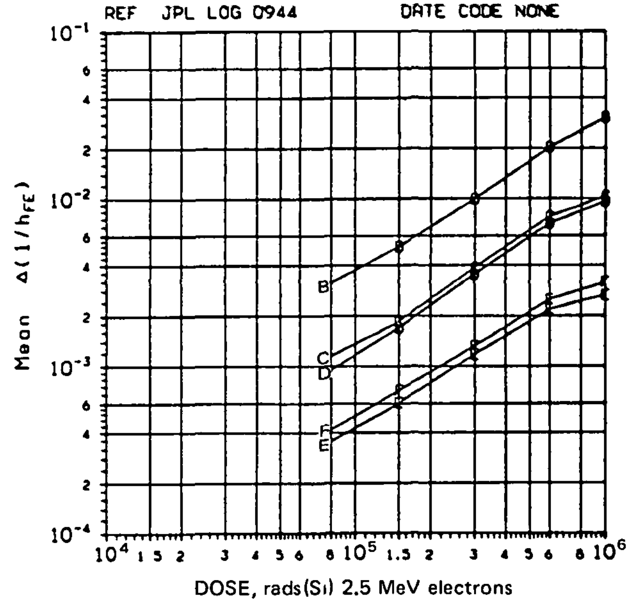


DOSE, rads(Si) 2.5 MeV electrons

Δ(1/h_{FE}) VS DOSE

TABLE OF NORMAL STANDARD DEVIATIONS						
CURVE	I_c (mA)	V_{CE} (v)	DOSE, kilorads(Si) 75	150	300	600
B	1000	20.0	0003	0033	0110	0146
C	1000	500	0004	0038	0122	0162
D	1.000	500	0003	0019	0046	.0056
E	1 000	20 0	0002	0017	0042	0051
F	10 00	20 0	0001	0005	0010	0012

DEVICE TYPE. 2N2920 TRANSISTOR DUAL NPN
MFG: TIX 6 DEVICES TEST DATE 1-05-83
REF JPL LOG 0944 DATE CODE NONE

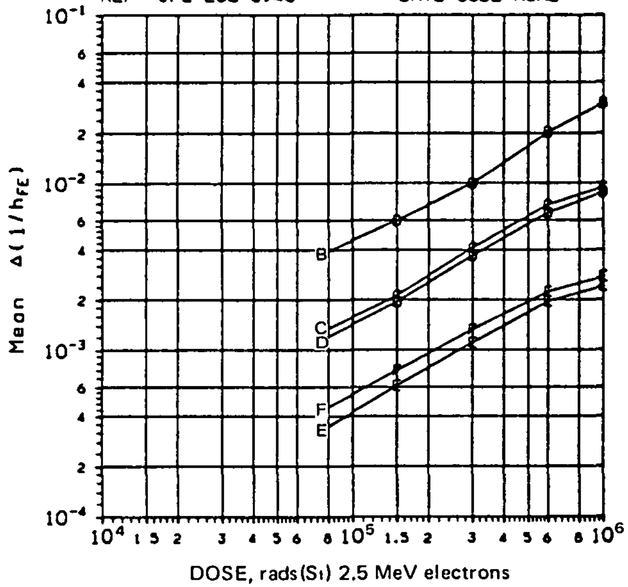


DOSE, rads(Si) 2.5 MeV electrons

Δ(1/h_{FE}) VS DOSE

TABLE OF NORMAL STANDARD DEVIATIONS						
CURVE	I_c (mA)	V_{CE} (v)	DOSE, kilorads(Si) 75	150	300	600
B	1000	500	.0007	.0026	0076	0092
C	1.000	500	0003	0011	.0022	0026
D	1 000	20 0	0002	0009	.0021	.0024
E	10.00	20.0	0001	0003	0004	.0005
F	10 00	500	0001	0003	0005	0006

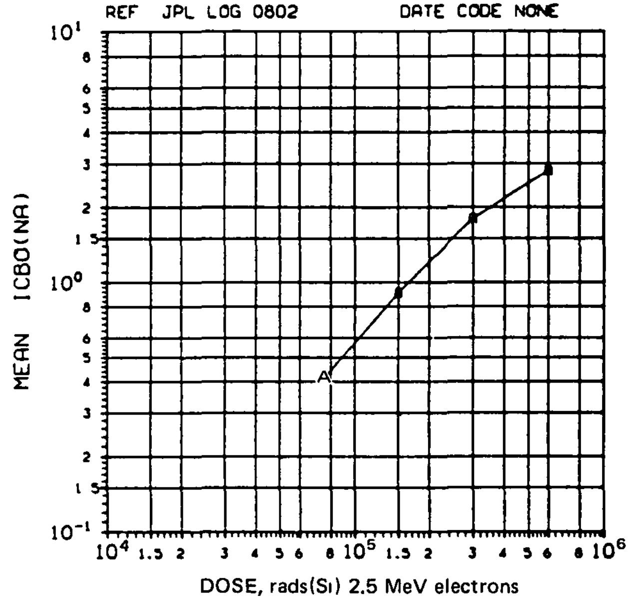
DEVICE TYPE· 2N2920 TRANSISTOR DUAL NPN
MFG: TIX 6 DEVICES TEST DATE 1-06-83
REF· JPL LOG 0948 DATE CODE NONE



Δ(1/h_{FE}) VS DOSE

TABLE OF NORMAL STANDARD DEVIATIONS						
CURVE	I_C (mA)	V_{CE} (v)	DOSE, kilorads(Si) 75	150	300	600
B	.1000	500	.0004	0014	0062	0106
C	1 000	.500	.0002	0008	0025	.0035
D	1 000	20 0	0001	0007	0022	0034
E	10.00	20 0	0001	0002	.0006	0008
F	10.00	.500	0001	.0003	.0007	0008

DEVICE TYPE 2N2920 NPN LOW POWER TRANSISTOR
MFG. TIX 6 DEVICES TEST DATE 1-6-82
REF JPL LOG 0802 DATE CODE NONE

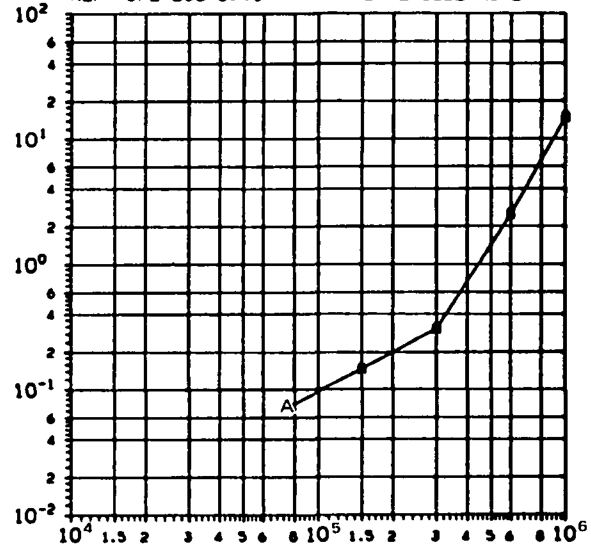


(1) ICBO IN NA(VCE=30V): VS DOSE

TABLE OF NORMAL STANDARD DEVIATIONS				
CURVE	DOSE, kilorads(Si) 75	150	300	600
A	1260	2884	7600	1.470

INITIAL MEAN VALUE ICBO(NA) = 5.77×10^{-2}

DEVICE TYPE: 2N2920 TRANSISTOR DUAL NPN
MFG: TIX 6 DEVICES TEST DATE 12-3-82
REF: JPL LOG 0941 DATE CODE NONE

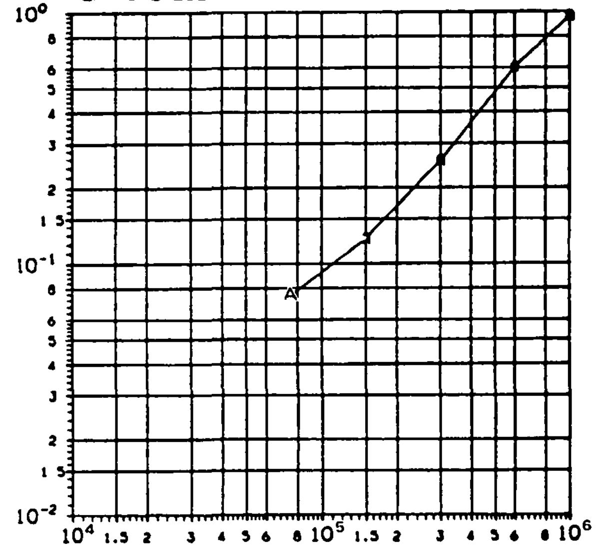


(1)ICBO (VCB=30V) IN NA: VS DOSE

TABLE OF NORMAL STANDARD DEVIATIONS					
CURVE	DOSE, kilorads(Si)				
	75	150	300	600	1000
A	.0235	.0223	.0316	4.616	33.91

INITIAL MEAN VALUE ICBO (NA) = 8.95×10^{-2}

DEVICE TYPE: 2N2920 TRANSISTOR DUAL NPN
MFG: TIX 6 DEVICES TEST DATE 12-20-82
REF: JPL LOG 0946 DATE CODE NONE

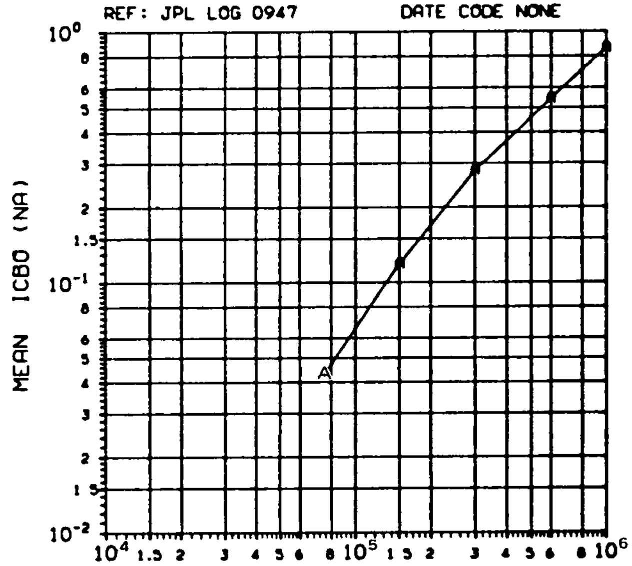


(1)ICBO (VCB=30V) IN NA: VS DOSE

TABLE OF NORMAL STANDARD DEVIATIONS					
CURVE	DOSE, kilorads(Si)				
	75	150	300	600	1000
A	0173	.0191	0331	.0523	.1314

INITIAL MEAN VALUE ICBO (NA) = 8.42×10^{-2}

DEVICE TYPE. 2N2920 TRANSISTOR DUAL NPN
MFG: TIX 6 DEVICES TEST DATE 12-8-82
REF: JPL LOG 0947 DATE CODE NONE

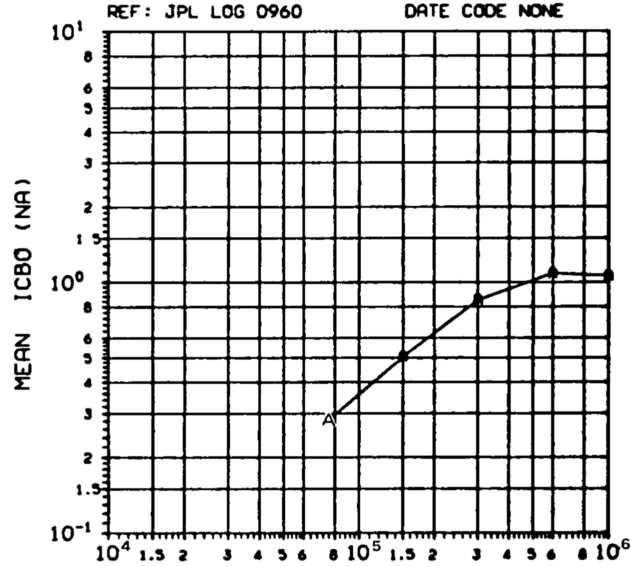


(1)ICBO (VCB=30V) IN NA: VS DOSE

TABLE OF NORMAL STANDARD DEVIATIONS					
CURVE	DOSE, kilorads(Si)				
	75	150	300	600	1000
A	.0134	.0290	.0320	.0568	.1240

INITIAL MEAN VALUE ICBO (NA) = 7.13×10^{-2}

DEVICE TYPE. 2N2920 TRANSISTOR DUAL NPN
MFG: TIX 6 DEVICES TEST DATE 1-04-83
REF: JPL LOG 0960 DATE CODE NONE



(1)ICBO (VCB=30V) IN NA: VS DOSE

TABLE OF NORMAL STANDARD DEVIATIONS					
CURVE	DOSE, kilorads(Si)				
	75	150	300	600	1000
A	.1425	.3433	.7930	1.069	.9699

INITIAL MEAN VALUE ICBO (NA) = 1.53×10^{-1}

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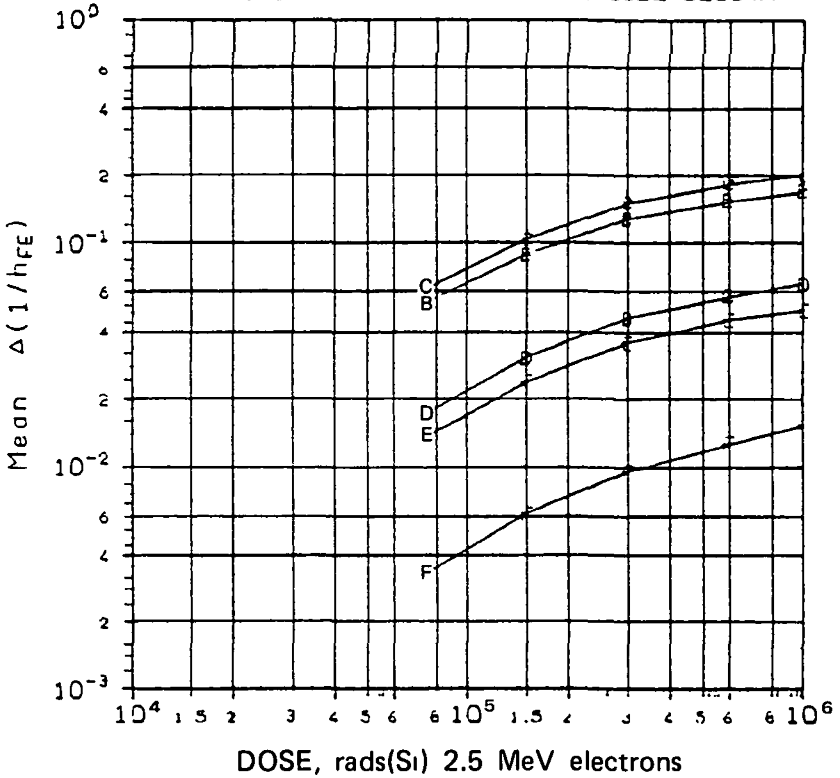
DEVICE TYPE 2N3019 TRANSISTOR NPN
MFG: MOT 3 DEVICES TEST DATE 8-14-84
REF: JPL LOG 1070 DATE CODE SL007A



$\Delta(1/h_{FE})$ VS DOSE

TABLE OF NORMAL STANDARD DEVIATIONS						
CURVE	I_C (mA)	V_{CE} (v)	DOSE, kilorads(Si) 75	150	300	600
B	1 000	20 0	0533	0672	.0620	0634
C	1 000	500	0556	0694	0648	0653
D	10 00	500	0069	0073	0062	0060
E	10 00	20 0	0065	0070	0067	0066
F	100 0	20 0	0008	0010	0003	0006

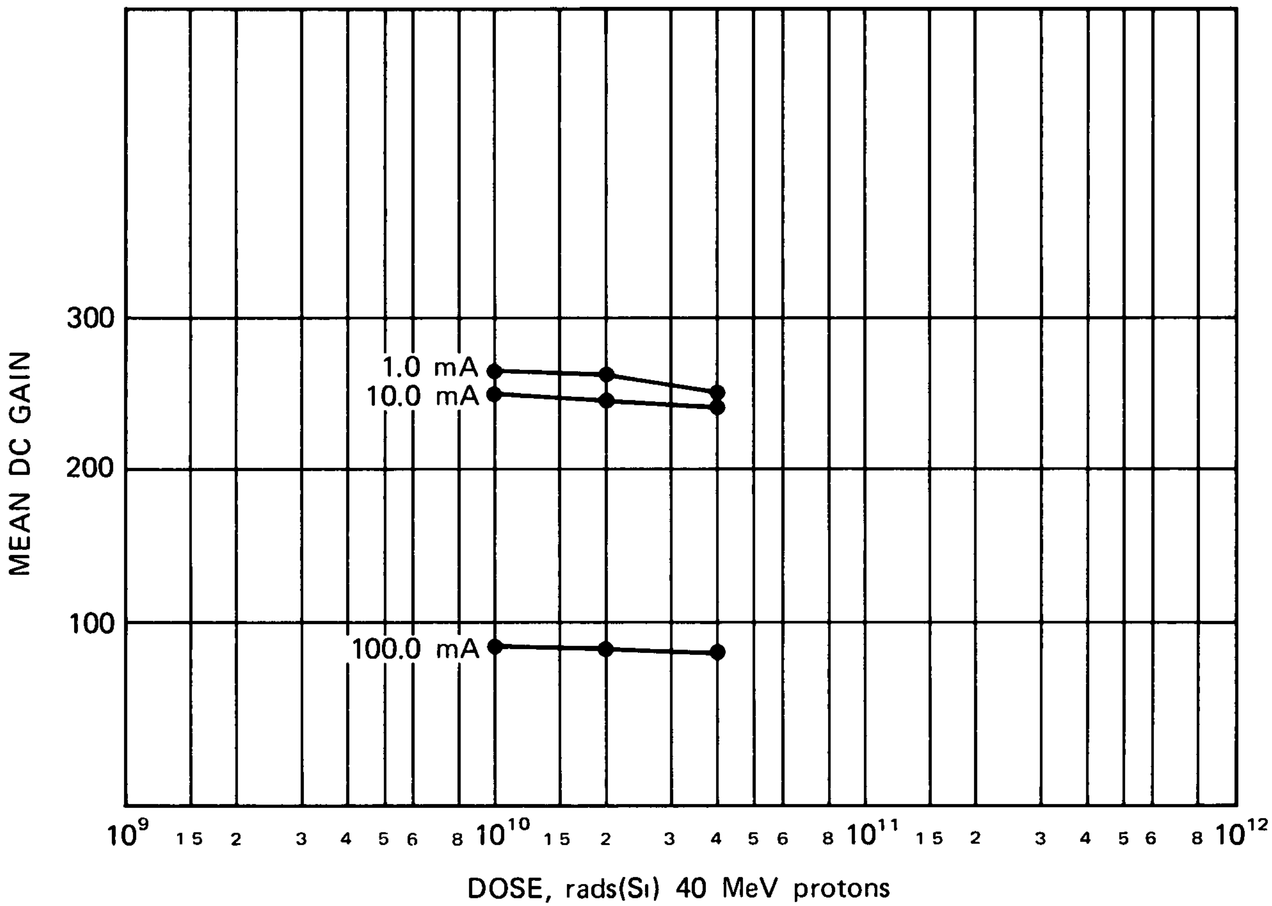
DEVICE TYPE: 2N3350

MFG: MOT 6 DEVICES

REF: JPL LOG 0762

TEST DATE: 7/16/81

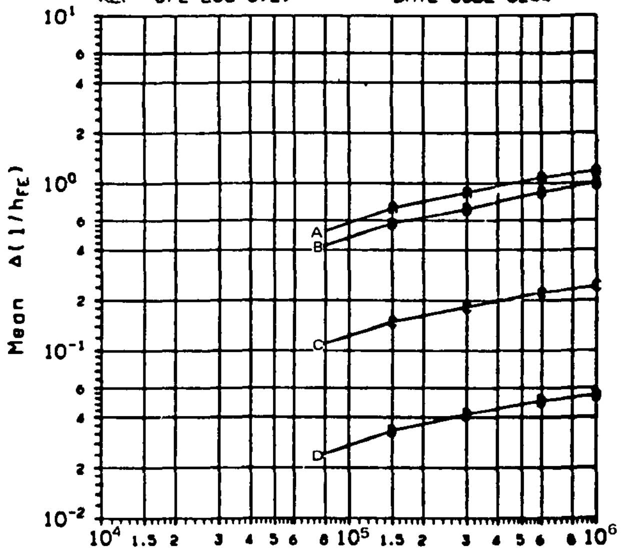
DATE CODE: NONE



DC GAIN vs DOSE

INITIAL MEAN DC GAIN VALUE = 268.0 @ 1.0 mA
241.3 @ 10.0 mA
81.8 @ 100.0 mA

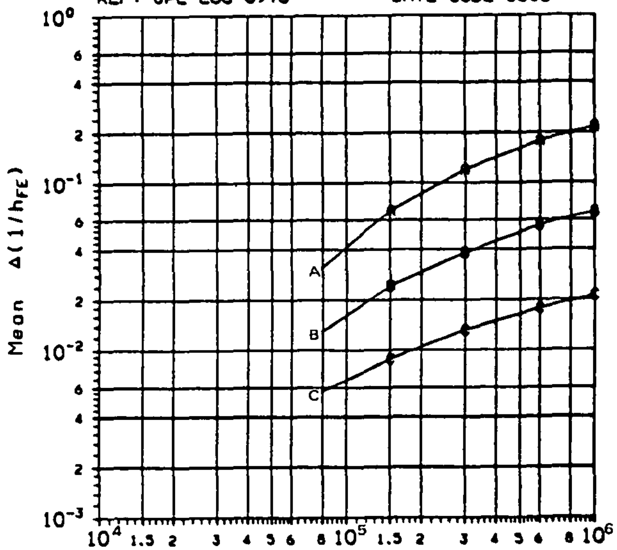
DEVICE TYPE: 2N3501 TRANSISTOR NPN
MFG: MOT 6 DEVICES TEST DATE 12-2-82
REF JPL LOG 0929 DATE CODE 8244



$\Delta(1/h_{FE})$ VS DOSE

TABLE OF NORMAL STANDARD DEVIATIONS						
CURVE	I_C (mA)	V_{CE} (v)	DOSE, kilorads(Si) 75	150	300	600
A	.1000	20.0	.0953	.1223	.1497	.1556
B	.1000	20.0	.0828	.0927	.1339	.1407
C	1.000	20 0	.0174	.0192	.0302	.0323
D	10 00	20 0	.0030	.0034	.0051	.0053

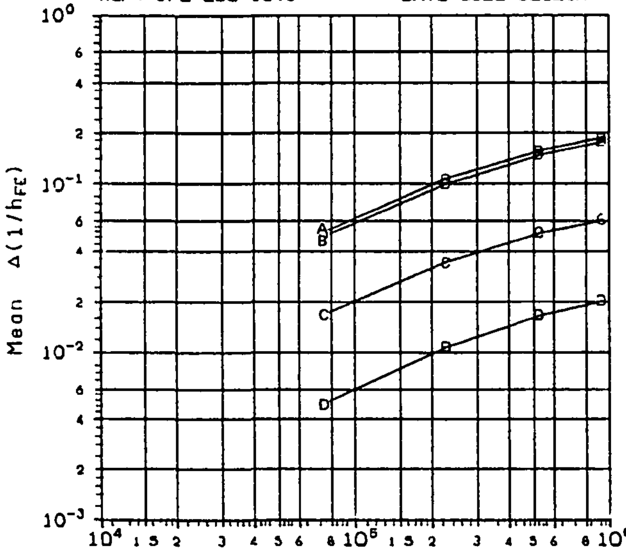
DEVICE TYPE: 2N3501 TRANSISTOR NPN
MFG: MOT 6 DEVICES TEST DATE 02-08-83
REF: JPL LOG 0973 DATE CODE 8313



$\Delta(1/h_{FE})$ VS DOSE

TABLE OF NORMAL STANDARD DEVIATIONS						
CURVE	I_C (mA)	V_{CE} (v)	DOSE, kilorads(Si) 75	150	300	600
A	.1000	20.0	0033	.0059	.0074	0108
B	1 000	20.0	.0012	.0020	.0019	.0022
C	10.00	20.0	.0004	0003	0002	.0006

DEVICE TYPE: 2N3501 NPN TRANSISTOR
MFG: MOT 5 DEVICES TEST DATE 9-7-84
REF: JPL LOG 1071 DATE CODE SL026R

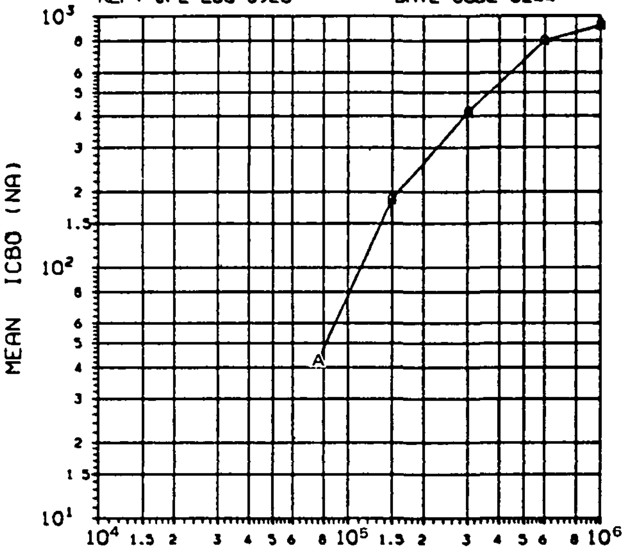


DOSE, rads(Si) 2.5 MeV electrons

$\Delta(1/h_{FE})$ VS DOSE

TABLE OF NORMAL STANDARD DEVIATIONS						
CURVE	I_c (mA)	V_{CE} (v)	DOSE, kilorads(Si) 75	225	525	925
A	.1000	20 0	0137	0216	.0209	0190
B	1000	20 0	0130	0234	0213	0177
C	1 000	20 0	0029	0049	0051	0050
D	10 00	20.0	.0007	.0014	.0019	.0021

DEVICE TYPE: 2N3501 TRANSISTOR
MFG. MOT 6 DEVICES TEST DATE 11-22-82
REF. JPL LOG 0928 DATE CODE 8244



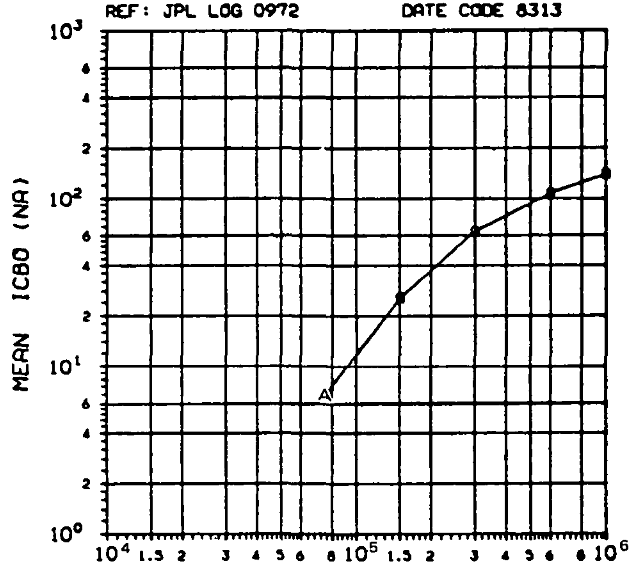
DOSE, rads(Si) 2.5 MeV electrons

(1)ICBO (VCB=50V) IN NA: VS DOSE

TABLE OF NORMAL STANDARD DEVIATIONS					
CURVE	DOSE, kilorads(Si) 75	150	300	600	1000
A	19.53	20.83	70.95	305.7	266.2

INITIAL MEAN VALUE ICBO (NA) = $1.10\times10^{+0}$

DEVICE TYPE: 2N3501 TRANSISTOR NPN
MFG: MOT 6 DEVICES TEST DATE 02-08-83
REF: JPL LOG 0972 DATE CODE 8313

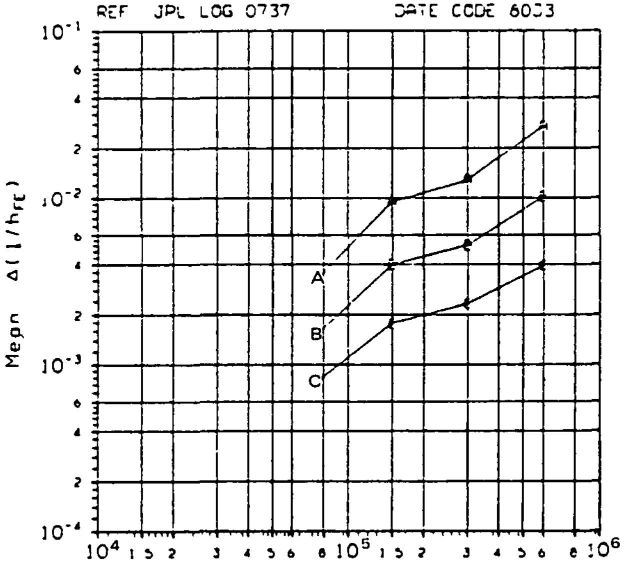


(1)ICBO (VCB=50V) IN NA: VS DOSE

TABLE OF NORMAL STANDARD DEVIATIONS					
CURVE	DOSE, kilorads(Si)				
	75	150	300	600	1000
A	1.157	5.477	15.41	19.69	21.54

INITIAL MEAN VALUE ICBO (NA) = 5.38×10^{-2}

DEVICE TYPE 2N3637 PNP POWER TRANSISTOR
MFG. MOT 8 DEVICES TEST DATE 6-5-81
REF JPL LOG 0737 DATE CODE 6033

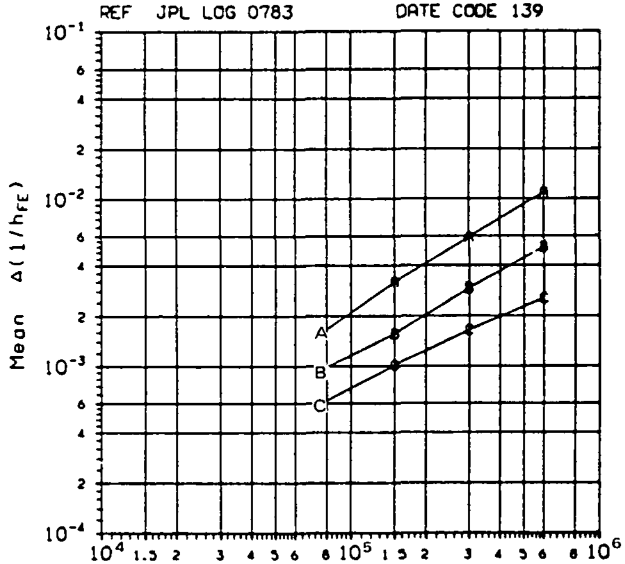


DOSE, rads(Si) Co^{60} Gammas

Δ(1/h_{FE}) VS DOSE

TABLE OF NORMAL STANDARD DEVIATIONS						
CURVE	I_C (mA)	V_{CE} (v)	DOSE, kilorads(Si) 75	150	300	600
A	1000	20 0	0007	0046	0025	0045
B	1 000	20 0	0003	0015	0009	0016
C	10 00	20 0	0002	0005	0004	0004

DEVICE TYPE 2N3637 PNP POWER TRANSISTOR
MFG. MOT 8 DEVICES TEST DATE 9-25-81
REF JPL LOG 0783 DATE CODE 139



DOSE, rads(Si) 2 5 MeV electrons

Δ(1/h_{FE}) VS DOSE

TABLE OF NORMAL STANDARD DEVIATIONS						
CURVE	I_C (mA)	V_{CE} (v)	DOSE, kilorads(Si) 75	150	300	600
A	1000	20 0	0007	0016	0041	0099
B	1 00C	20 0	0005	0009	0019	0037
C	10 00	20 0	0003	0006	0010	0014

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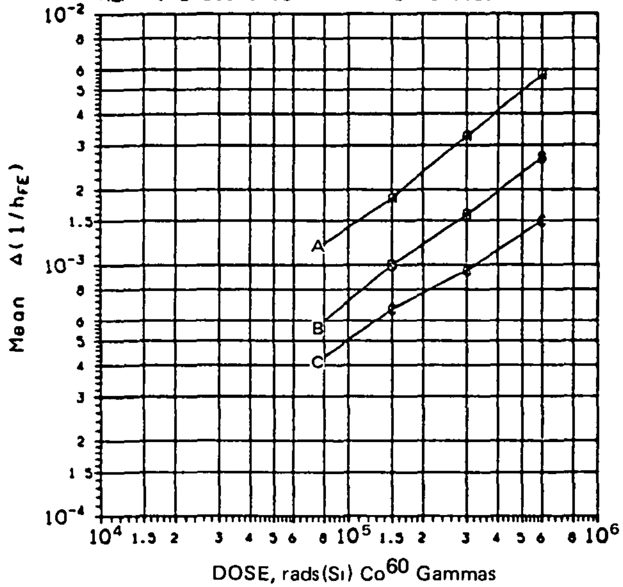
DEVICE TYPE. 2N3637 PNP POWER TRANSISTOR
MFG. MOT 8 DEVICES TEST DATE 10-7-81
REF: JPL LOG 0782 DATE CODE 139



$\Delta(1/h_{FE})$ VS DOSE

TABLE OF NORMAL STANDARD DEVIATIONS						
CURVE	I_C (mA)	V_{CE} (v)	DOSE, kilorads(Si) 75	150	300	600
A	.1000	20.0	.0007	0011	.0016	.0023
B	1.000	20.0	.0003	0004	.0005	.0008
C	10.00	20.0	0002	.0002	0003	.0003

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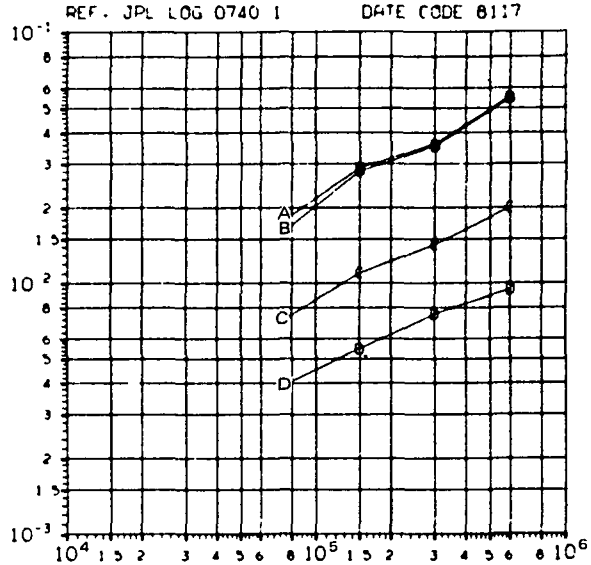
DEVICE TYPE. 2N3700 NPN LOW POWER TRANSISTOR
MFG: NSC 7 DEVICES TEST DATE 6-9-81
REF. JPL LOG 0740 1 DATE CODE 8117

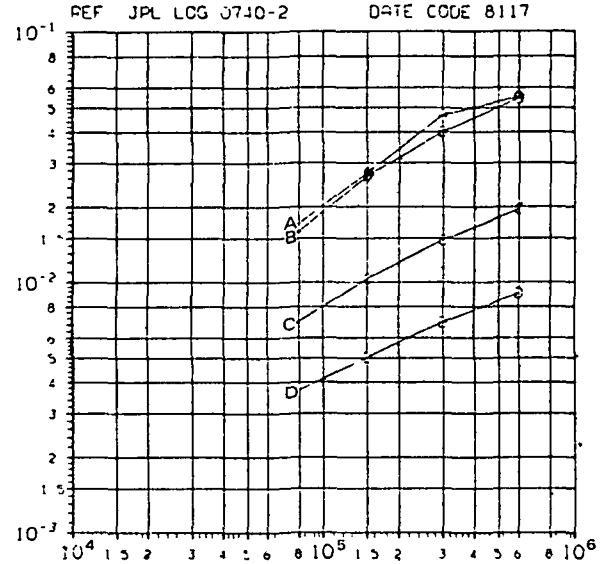


DOSE, rads(Si) Co^{60} Gammas

Δ(1/h_{FE}) VS DOSE

TABLE OF NORMAL STANDARD DEVIATIONS						
CURVE	I_C (mA)	V_{CE} (v)	DOSE, kilorads(Si) 75	150	300	600
A	1 000	20 0	0015	0021	0022	0028
B	1.000	20 0	0024	0040	0045	0063
C	10 00	20 0	0007	0009	0009	0013
D	100.0	20 0	0004	.0005	0006	0007

DEVICE TYPE 2N3700 NPN LOW POWER TRANSISTOR
MFG. NSC 8 DEVICES TEST DATE 6-9-81
REF JPL LOG 0740-2 DATE CODE 8117

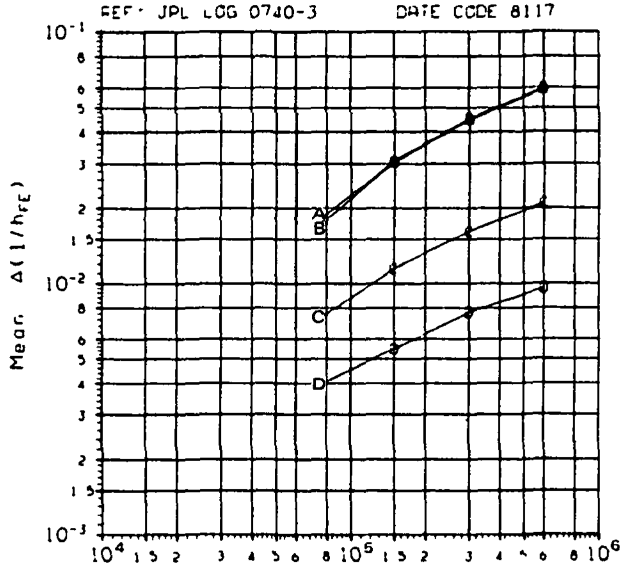


DOSE, rads(Si) Co^{60} Gammas

Δ(1/h_{FE}) VS DOSE

TABLE OF NORMAL STANDARD DEVIATIONS						
CURVE	I_C (mA)	V_{CE} (v)	DOSE, kilorads(Si) 75	150	300	600
A	1 000	20 0	0011	0029	0187	0038
B	1 000	20 0	0015	0035	0034	0048
C	10 00	20 0	0006	0011	0011	0015
D	100 0	20 0	0004	0006	0008	0009

DEVICE TYPE 2N3700 NPN LOW POWER TRANSISTOR
MFG. NSC 8 DEVICES TEST DATE 6-9-81
REF: JPL LOG 0740-3 DATE CODE 8117

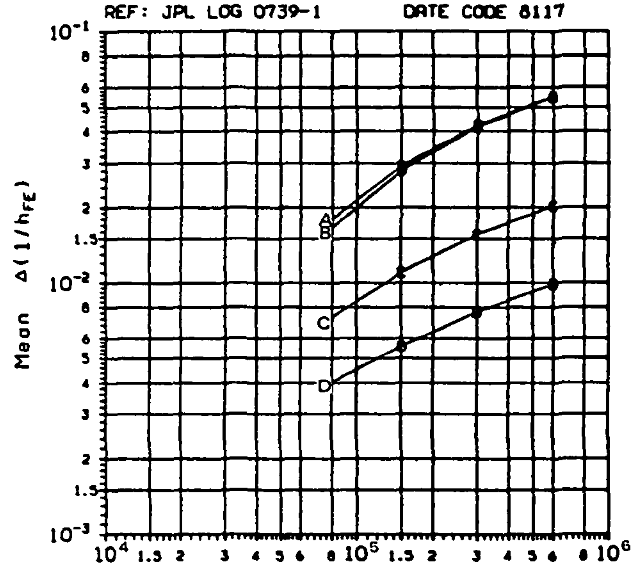


DOSE, rads(Si) Co^{60} Gammas

$\Delta(1/h_{FE})$ VS DOSE

TABLE OF NORMAL STANDARD DEVIATIONS						
CURVE	I_c (mA)	V_{CE} (v)	DOSE, kilorads(Si) 75	150	300	600
A	1 000	20 0	0007	0008	0010	0017
B	1 000	20 0	0007	0013	0016	0023
C	10 00	20 0	0004	0004	0005	0007
D	100 0	20 0	0003	0003	0005	0006

DEVICE TYPE: 2N3700 LOW POWER TRANSISTOR
MFG: NSC 8 DEVICES TEST DATE 11-11-81
REF: JPL LOG 0739-1 DATE CODE 8117

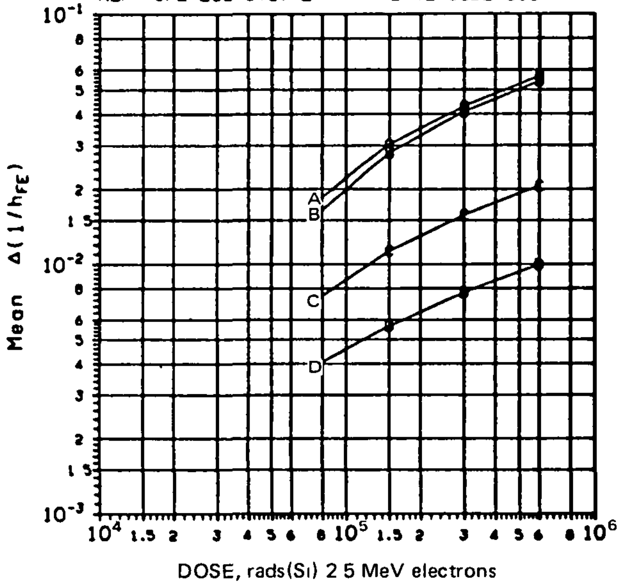


DOSE, rads(Si) 2.5 MeV electrons

$\Delta(1/h_{FE})$ VS DOSE

TABLE OF NORMAL STANDARD DEVIATIONS						
CURVE	I_c (mA)	V_{CE} (v)	DOSE, kilorads(Si) 75	150	300	600
A	1.000	20.0	.0019	.0030	.0037	.0041
B	10.00	20.0	.0027	.0042	.0059	.0076
C	100.0	20.0	.0008	.0011	.0014	.0018
D	*****	****	.0006	.0007	.0009	.0011

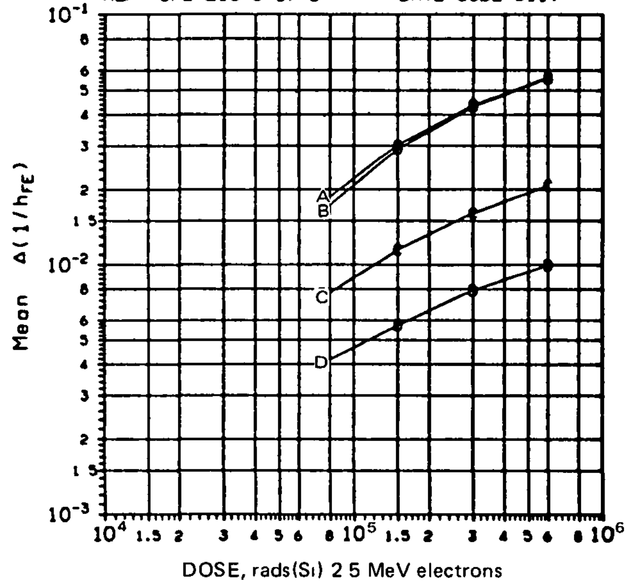
DEVICE TYPE: 2N3700 LOW POWER TRANSISTOR
MFG: NSC 5 DEVICES TEST DATE 11-11-81
REF: JPL LOG 0739-2 DATE CODE 8117



Δ(1/h$_{FE}$) VS DOSE

TABLE OF NORMAL STANDARD DEVIATIONS						
CURVE	I_c (mA)	V_{CE} (v)	DOSE, kilorads(Si) 75	150	300	600
A	1.000	20.0	.0013	.0015	.0020	.0024
B	10.00	20.0	.0022	.0029	.0040	.0046
C	100.0	20.0	.0005	.0006	.0007	.0009
D	*****	****	.0003	.0004	.0005	.0006

DEVICE TYPE: 2N3700 LOW POWER TRANSISTOR
MFG: NSC 8 DEVICES TEST DATE 11-11-81
REF: JPL LOG 0739-3 DATE CODE 8117



Δ(1/h$_{FE}$) VS DOSE

TABLE OF NORMAL STANDARD DEVIATIONS						
CURVE	I_c (mA)	V_{CE} (v)	DOSE, kilorads(Si) 75	150	300	600
A	1.000	20.0	.0012	.0017	.0020	.0027
B	10.00	20.0	.0018	.0026	.0034	.0046
C	100.0	20.0	.0005	.0007	.0008	.0009
D	*****	****	.0003	.0003	.0004	.0004

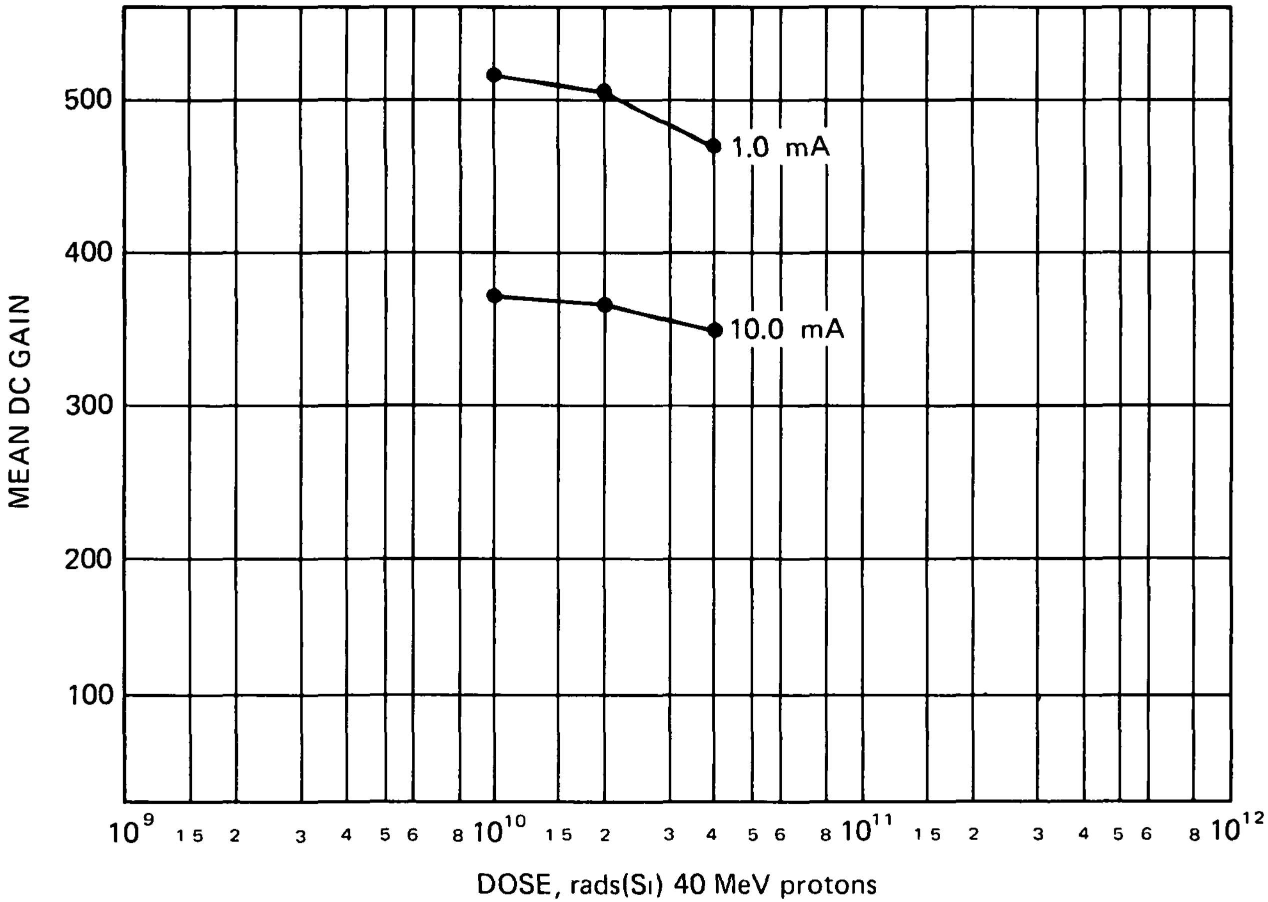
DEVICE TYPE. 2N3799

MFG: TIX 6 DEVICES

REF: JPL LOG 0769

TEST DATE. 7/16/81

DATE CODE: NONE



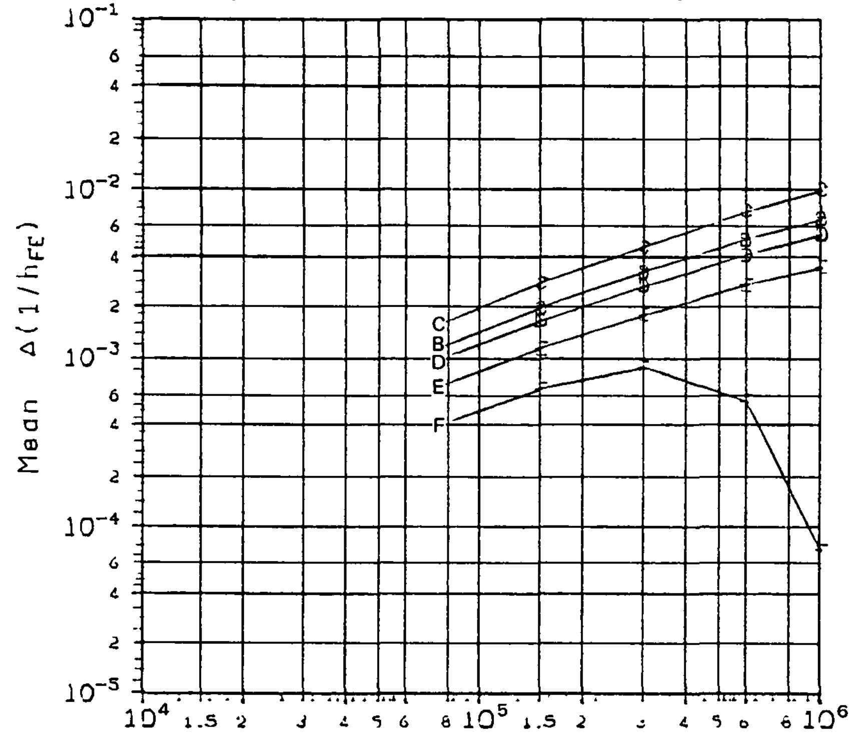
DC GAIN vs DOSE

INITIAL MEAN DC GAIN VALUE = 528.8 @ 1.0 mA
384.7 @ 10.0 mA

DEVICE TYPE: 2N3964 PNP TRANSISTOR

MFG: MOT 5 DEVICES TEST DATE 2-8-85

REF: JPL LOG 1076 DATE CODE SL555

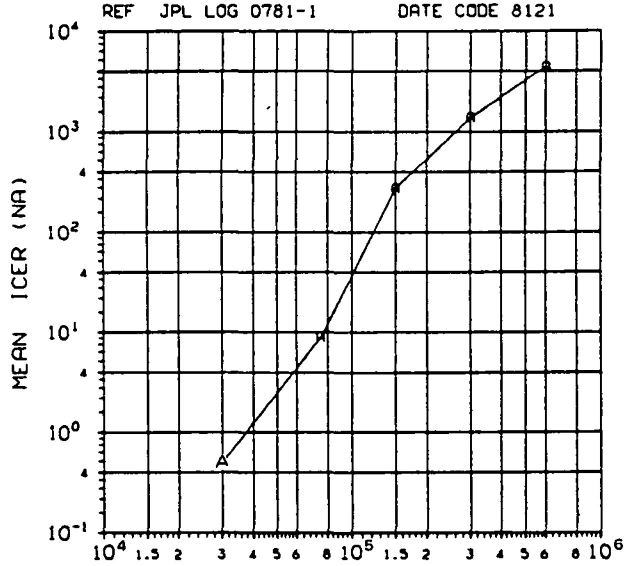


DOSE, rads(Si) 2.5 MeV electrons

$\Delta(1/h_{FE})$ VS DOSE

TABLE OF NORMAL STANDARD DEVIATIONS						
CURVE	I_C (mA)	V_{CE} (v)	DOSE, kilorads(Si) 75	150	300	600
B	1000	30.0	0005	.0005	.0006	.0005
C	1000	500	0006	.0006	0009	0007
D	1 000	.500	0003	.0004	.0004	0003
E	1 000	30.0	0002	.0003	.0003	0002
F	20.00	30.0	.0001	0001	0010	.0001

DEVICE TYPE 2N4150 NPN TRANSISTOR
MFG. SOD 6 DEVICES TEST DATE 7-30-81
REF JPL LOG 0781-1 DATE CODE 8121



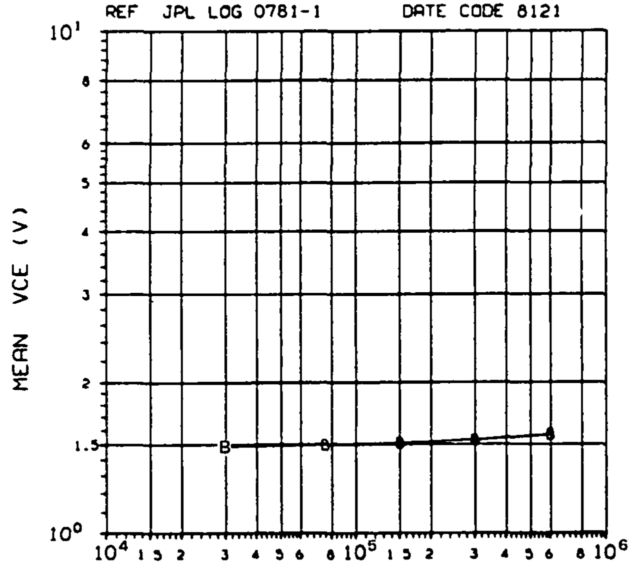
DOSE, rads(Si) 2 5 MeV electrons

(1)ICER IN NA,VCE=10 0V,RBE=1 0KOHM VS DOSE

TABLE OF NORMAL STANDARD DEVIATIONS					
CURVE	DOSE, kilorads(Si)				
	30	75	150	300	600
A	2352	11 22	359 2	1168	1763

INITIAL MEAN VALUE ICER (NA) = 7 70X10^{-1}

DEVICE TYPE. 2N4150 NPN TRANSISTOR
MFG. SOD 6 DEVICES TEST DATE 7-30-81
REF JPL LOG 0781-1 DATE CODE 8121



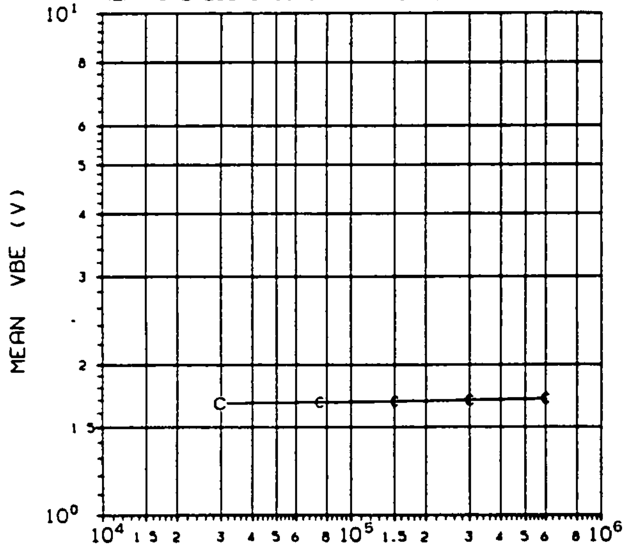
DOSE, rads(Si) 2.5 MeV electrons

(2)VCE(SAT) IN VOLTS,IB=500MA,IC=5 VS DOSE

TABLE OF NORMAL STANDARD DEVIATIONS					
CURVE	DOSE, kilorads(Si)				
	30	75	150	300	600
B	1082	1069	1024	1088	.1175

INITIAL MEAN VALUE VCE (V) = 1.49X10^{-0}

DEVICE TYPE 2N4150 NPN TRANSISTOR
MFG SOD 6 DEVICES TEST DATE 7-30-81
REF JPL LOG 0781-1 DATE CODE 8121

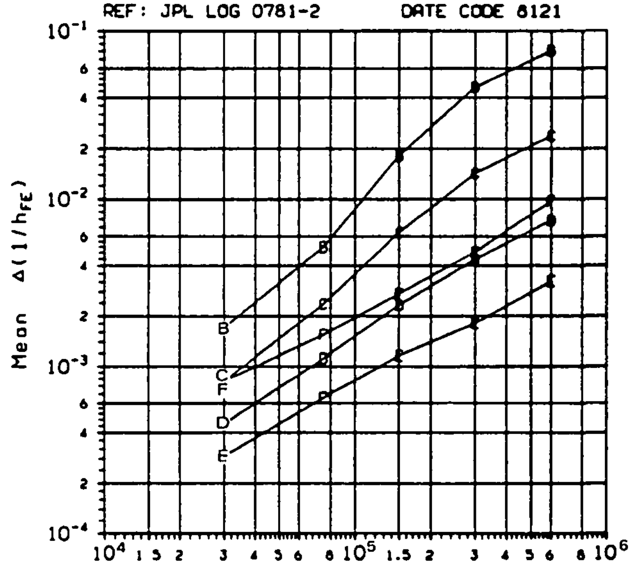


(3)VBE(SAT) IN VOLTS, IB=500MA; IC=5. VS DOSE

TABLE OF NORMAL STANDARD DEVIATIONS					
CURVE	DOSE, kilorads(Si)				
	30	75	150	300	600
C	0689	0703	0624	0697	0727

INITIAL MEAN VALUE VBE (V) = 1 68X10⁻⁰

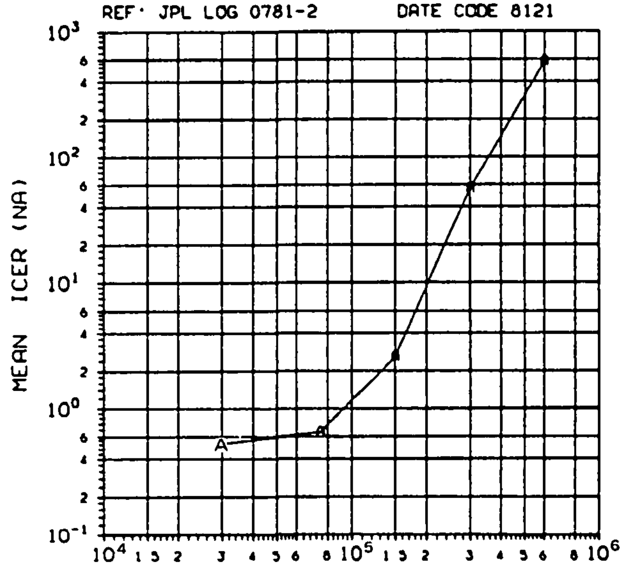
DEVICE TYPE. 2N4150 NPN TRANSISTOR
MFG: SOD 6 DEVICES TEST DATE 7-31-81
REF: JPL LOG 0781-2 DATE CODE 8121



Δ(1/h_{FE}) VS DOSE

TABLE OF NORMAL STANDARD DEVIATIONS						
CURVE	I_C (mA)	V_{CE} (v)	DOSE, kilorads(Si) 30	75	150	300
B	1.000	5.00	.0028	0110	.0160	.0291
C	10 00	5.00	.0007	0026	0044	.0054
D	100 0	5.00	.0001	0003	0008	.0009
E	1000.	5 00	.0001	.0002	.0002	.0003
F	5000.	2.00	0006	0010	.0013	0027

DEVICE TYPE: 2N4150 NPN TRANSISTOR
MFG. SOD 6 DEVICES TEST DATE 7-31-81
REF· JPL LOG 0781-2 DATE CODE 8121

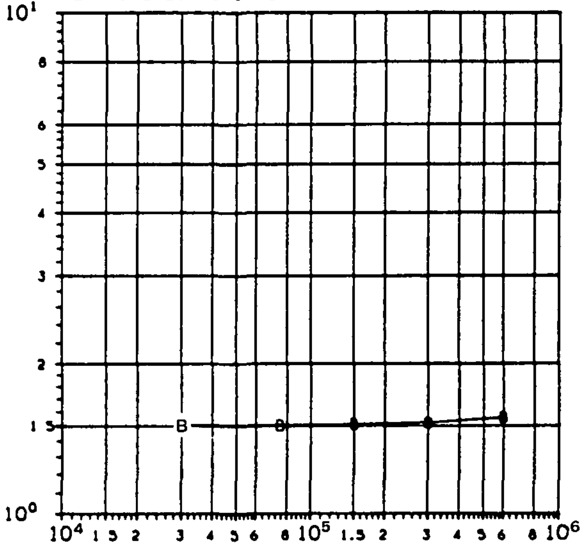


(1)ICER IN NA;VCE=10 0V;RBE=1 0KOHM VS DOSE

TABLE OF NORMAL STANDARD DEVIATIONS					
CURVE	DOSE, kilorads(Si) 30	75	150	300	600
A	5322	4326	3 538	103.3	920.5

INITIAL MEAN VALUE ICER (NA) = 4 82X10^{-1}

DEVICE TYPE: 2N4150 NPN TRANSISTOR
MFG: SOD 6 DEVICES TEST DATE 7-31-81
REF: JPL LOG 0781-2 DATE CODE 8121



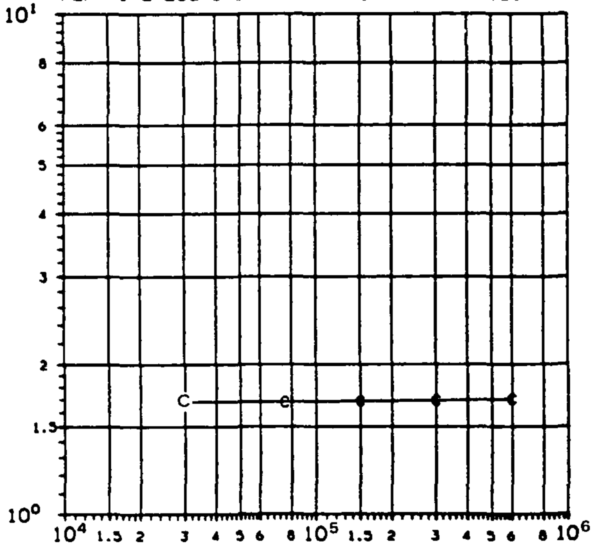
DOSE, rads(Si) 2.5 MeV electrons

(2)VCE(SAT) IN VOLTS;IB=500MA;IC=5. VS DOSE

TABLE OF NORMAL STANDARD DEVIATIONS					
CURVE	DOSE, kilorads(Si)				
	30	75	150	300	600
B	0871	0689	.0826	.0752	.0770

INITIAL MEAN VALUE VCE (V) = 1.50×10^{-0}

DEVICE TYPE: 2N4150 NPN TRANSISTOR
MFG: SOD 6 DEVICES TEST DATE 7-31-81
REF JPL LOG 0781-2 DATE CODE 8121



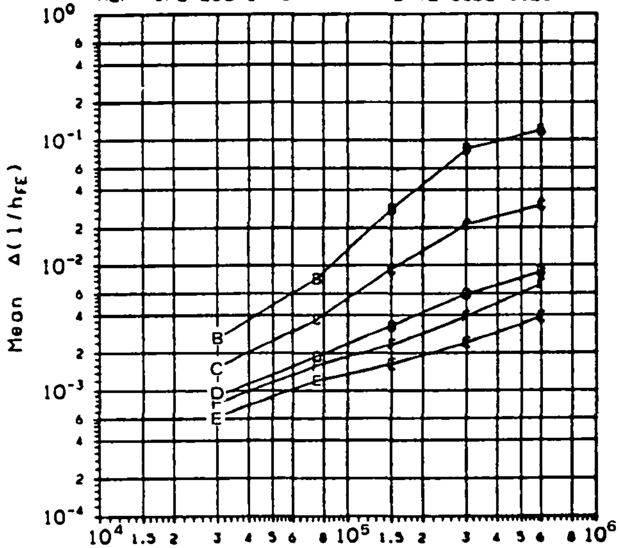
DOSE, rads(Si) 2.5 MeV electrons

(3)VBE(SAT) IN VOLTS;IB=500MA;IC=5. VS DOSE

TABLE OF NORMAL STANDARD DEVIATIONS					
CURVE	DOSE, kilorads(Si)				
	30	75	150	300	600
C	.0548	.0490	.0561	.0490	0519

INITIAL MEAN VALUE VBE (V) = 1.69×10^{-0}

DEVICE TYPE: 2N4150 NPN POWER TRANSISTOR
MFG: SOD 8 DEVICES TEST DATE 10-29-81
REF: JPL LOG 0795 DATE CODE 8120A

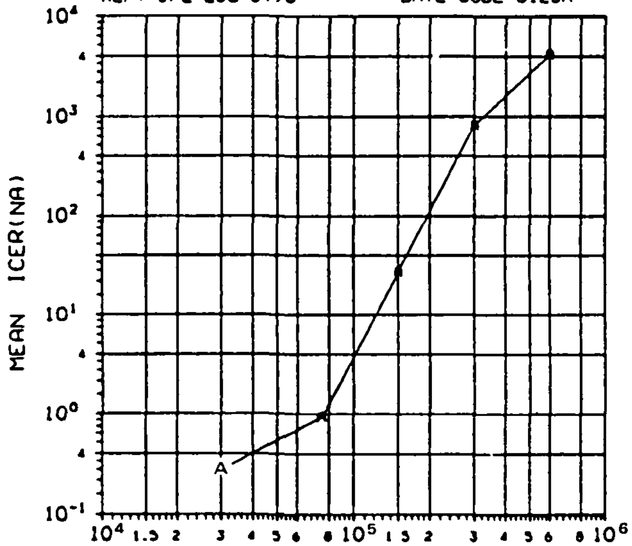


DOSE, rads(Si) 2 5 MeV electrons

Δ(1 / h_{FE}) VS DOSE

TABLE OF NORMAL STANDARD DEVIATIONS						
CURVE	I_c (mA)	V_{CE} (v)	DOSE, kilorads(Si)			
			30	75	150	300
B	1 000	5.00	0019	C053	0235	0374
C	10 00	5 00	0006	0014	.0044	0068
D	100 0	5 00	0002	0004	0009	0012
E	1000	5.00	0001	0002	.0003	0004
F	5000.	2 00	0002	0002	0003	0005

DEVICE TYPE· 2N4150 NPN POWER TRANSISTOR
MFG: SOD 8 DEVICES . TEST DATE 10-29-81
REF: JPL LOG 0795 DATE CODE 8120A



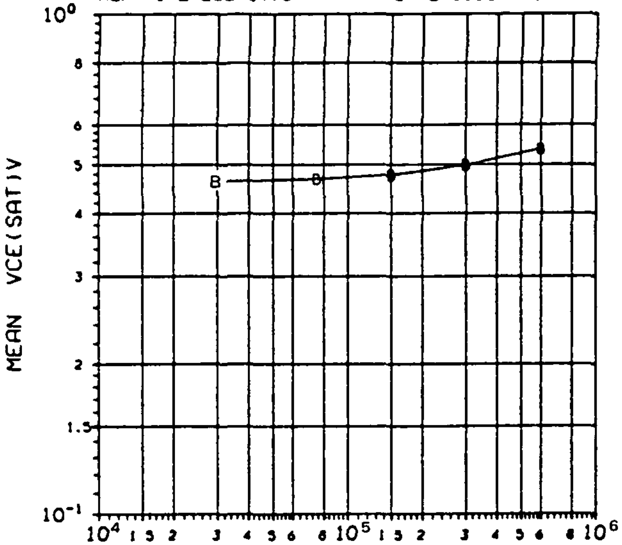
DOSE, rads(Si) 2 5 MeV electrons

(1)ICER(NA): VS DOSE

TABLE OF NORMAL STANDARD DEVIATIONS					
CURVE	DOSE, kilorads(Si)				
	30	75	150	300	600
A	.4232	1.697	20 44	659 9	3790.

INITIAL MEAN VALUE ICER(NA) = 1.56×10^{-1}

DEVICE TYPE: 2N4150 NPN POWER TRANSISTOR
MFG. SOD 8 DEVICES TEST DATE 10-29-81
REF: JPL LOG 0795 DATE CODE 8120A

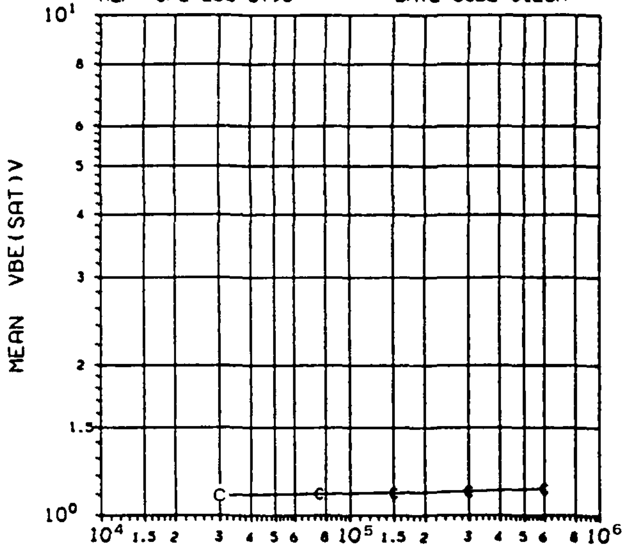


(2)VCE(SAT) VOLTS: VS DOSE

TABLE OF NORMAL STANDARD DEVIATIONS					
CURVE	DOSE, kilorads(Si)				
	30	75	150	300	600
B	0131	.0114	.0109	.0122	.0155

INITIAL MEAN VALUE VCE(SAT)V = $4.62X10^{-1}$

DEVICE TYPE: 2N4150 NPN POWER TRANSISTOR
MFG. SOD 8 DEVICES TEST DATE 10-29-81
REF JPL LOG 0795 DATE CODE 8120A

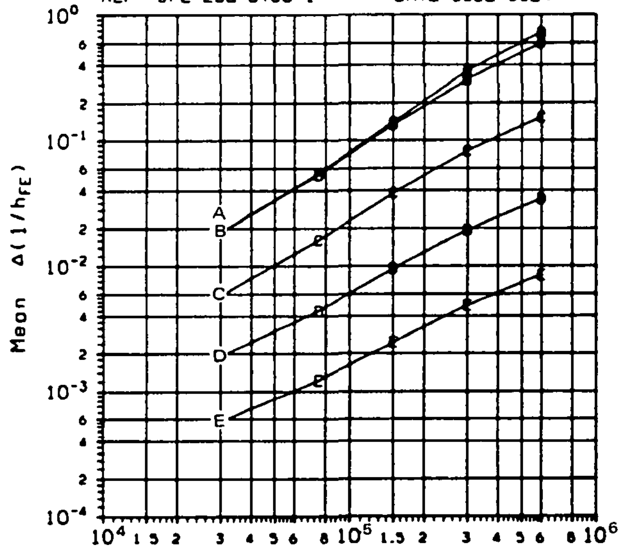


(3)VBE(SAT) VOLTS: VS DOSE

TABLE OF NORMAL STANDARD DEVIATIONS					
CURVE	DOSE, kilorads(Si)				
	30	75	150	300	600
C	.0043	.0045	.0045	0049	.0061

INITIAL MEAN VALUE VBE(SAT)V = $1.10X10^{-0}$

DEVICE TYPE. 2N4150 NPN POWER TRANSISTOR
MFG: UTR 5 DEVICES TEST DATE 6-24-81
REF JPL LOG 0736-1 DATE CODE 8024



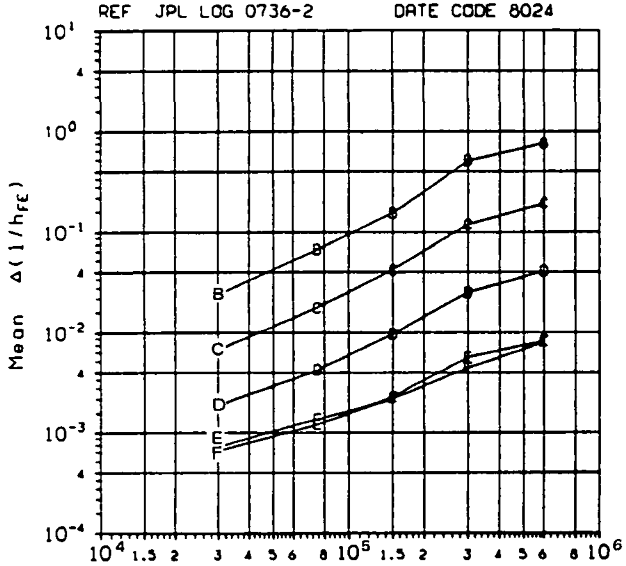
DOSE, rads(Si) 2.5 MeV electrons

$\Delta(1/h_{FE})$ VS DOSE

TABLE OF NORMAL STANDARD DEVIATIONS

CURVE	I_c (mA)	V_{CE} (v)	DOSE, kilorads(Si) 30	75	150	300
A	1 000	5.00	.0763	.1353	.1818	.0774
B	1 000	5 00	.0751	.1341	.1796	.1208
C	10 00	5 00	0212	.0370	.0477	.0357
D	100 0	5 00	0050	.0082	.0100	.0084
E	1000.	5 00	.0009	.0014	.0016	.0016

DEVICE TYPE 2N4150 NPN POWER TRANSISTOR
MFG UTR 6 DEVICES TEST DATE 6-24-81
REF JPL LOG 0736-2 DATE CODE 8024



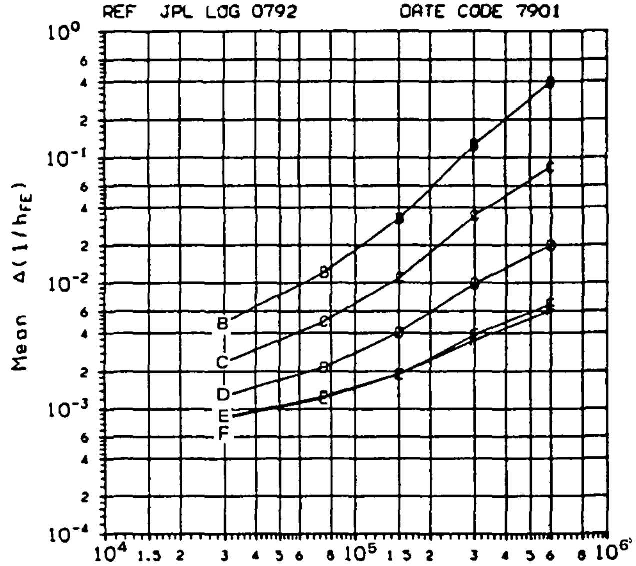
DOSE, rads(Si) 2 5 MeV electrons

$\Delta(1/h_{FE})$ VS DOSE

TABLE OF NORMAL STANDARD DEVIATIONS

CURVE	I_c (mA)	V_{CE} (v)	DOSE, kilorads(Si) 30	75	150	300
B	1 000	5.00	0679	1128	2106	4407
C	10 00	5 00	0169	0281	0431	0540
D	100 0	5 00	0035	0056	0077	.0095
E	1000	5 00	0007	0010	.0013	0040
F	5000	5 00	0002	0004	0008	0012

DEVICE TYPE 2N4150 NPN POWER TRANSISTOR
MFG. UTR 8 DEVICES TEST DATE 10-28-81
REF JPL LOG 0792 DATE CODE 7901

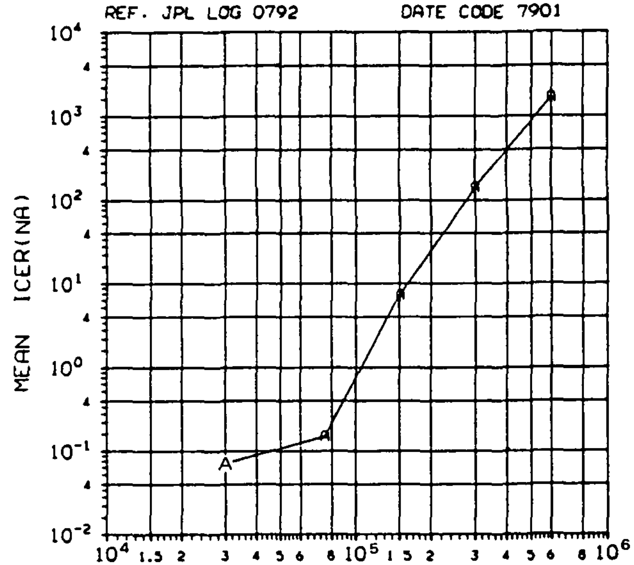


DOSE, rads(Si) 2.5 MeV electrons

$\Delta(1/h_{FE})$ VS DOSE

TABLE OF NORMAL STANDARD DEVIATIONS						
CURVE	I_c (mA)	V_{CE} (v)	DOSE, kilorads(Si) 30	75	150	300
B	1.000	5 00	0072	0145	0478	.1359
C	10.00	5 00	0024	0044	0101	0193
D	100 0	5.00	0007	0011	0019	0025
E	1000	5.00	0002	0002	0003	0003
F	5000.	2.00	0001	0001	.0002	0003

DEVICE TYPE 2N4150 NPN POWER TRANSISTOR
MFG. UTR 8 DEVICES TEST DATE 10-28-81
REF. JPL LOG 0792 DATE CODE 7901



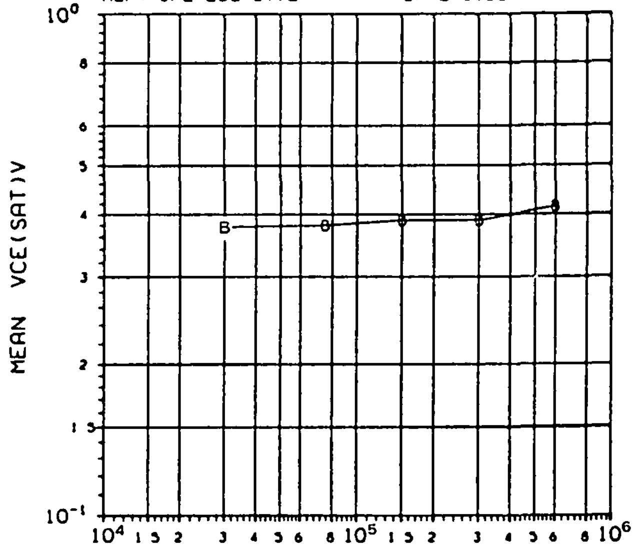
DOSE, rads(Si) 2 5 MeV electrons

(1)ICER(NA): VS DOSE

TABLE OF NORMAL STANDARD DEVIATIONS					
CURVE	DOSE, kilorads(Si) 30	75	150	300	600
A	0121	0826	19 44	366.9	3471

INITIAL MEAN VALUE ICER(NA) = 1 57X10^{-1}

DEVICE TYPE 2N4150 NPN POWER TRANSISTOR
MFG. UTR 8 DEVICES TEST DATE 10-28-81
REF. JPL LOG 0792 DATE CODE 7901



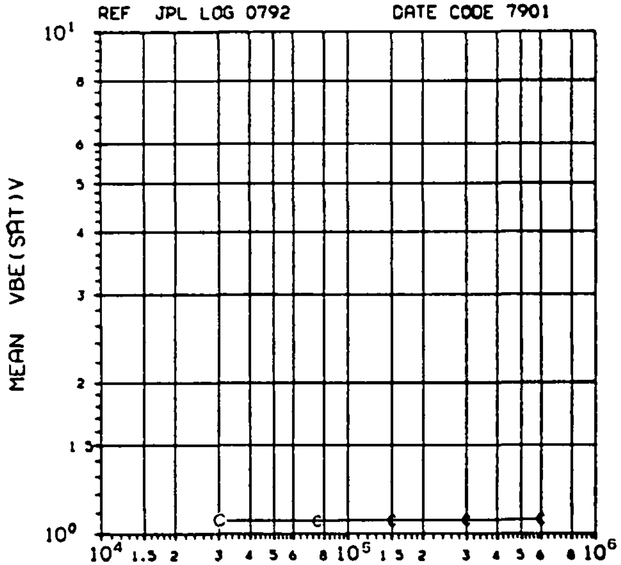
DOSE, rads(Si) 2 5 MeV electrons

(2)VCE(SAT) VOLTS: VS DOSE

TABLE OF NORMAL STANDARD DEVIATIONS					
CURVE	DOSE, kilorads(Si)				
	30	75	150	300	600
B	.0160	0155	0177	.0177	0205

INITIAL MEAN VALUE VCE(SAT)V = 3.79×10^{-1}

DEVICE TYPE 2N4150 NPN POWER TRANSISTOR
MFG. UTR 8 DEVICES TEST DATE 10-28-81
REF JPL LOG 0792 DATE CODE 7901



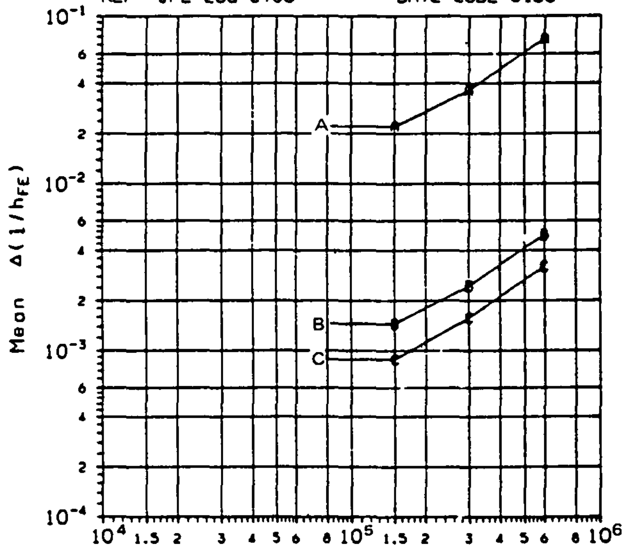
DOSE, rads(Si) 2 5 MeV electrons

(3)VBE(SAT) VOLTS: VS DOSE

TABLE OF NORMAL STANDARD DEVIATIONS					
CURVE	DOSE, kilorads(Si)				
	30	75	150	300	600
C	0128	0134	0147	.0147	.0138

INITIAL MEAN VALUE VBE(SAT)V = 1.06×10^{-0}

DEVICE TYPE. 96EJ103 NPN POWER TRANSISTOR
MFG: SOD 5 DEVICES TEST DATE 10-14-81
REF: JPL LOG 0788 DATE CODE 8135

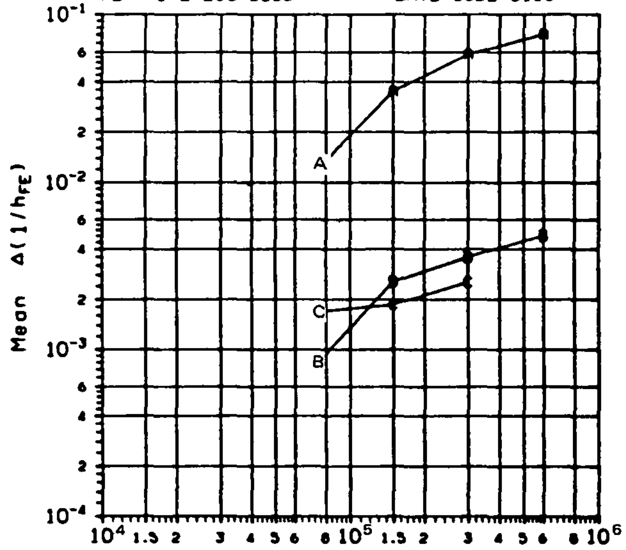


DOSE, rads(Si) 2.5 MeV electrons

$\Delta(1/h_{FE})$ VS DOSE

TABLE OF NORMAL STANDARD DEVIATIONS						
CURVE	I_C (A)	V_{CE} (v)	DOSE, kilorads(Si) 75	150	300	600
A	1000	20 0	0096	0096	0185	0447
B	4 000	5 00	0004	0004	.0008	0016
C	10 00	5.00	0002	0002	0003	0006

DEVICE TYPE. 96EJ103 POWER TRANSISTOR
MFG: SOD 5 DEVICES TEST DATE 2-3-82
REF: JPL LOG 0803 DATE CODE 8135

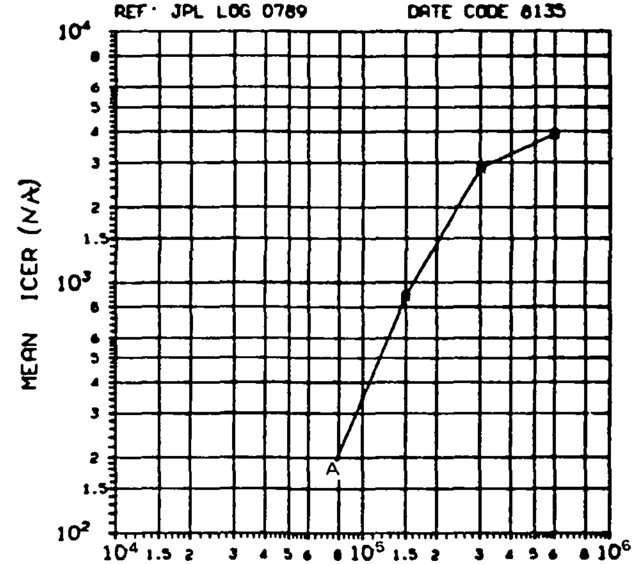


DOSE, rads(Si) Co^{60} Gammas

$\Delta(1/h_{FE})$ VS DOSE

TABLE OF NORMAL STANDARD DEVIATIONS						
CURVE	I_C (A)	V_{CE} (v)	DOSE, kilorads(Si) 75	150	300	600
A	.1000	20.0	.0069	.0197	.0358	.0515
B	4.000	5.00	.0005	.0006	.0015	.0020
C	10.00	5.00	.0010	.0003	.0004	****

DEVICE TYPE: 96EJ103 NPN POWER TRANSISTOR
MFG: SOD 5 DEVICES TEST DATE 10-16-81
REF: JPL LOG 0789 DATE CODE 8135



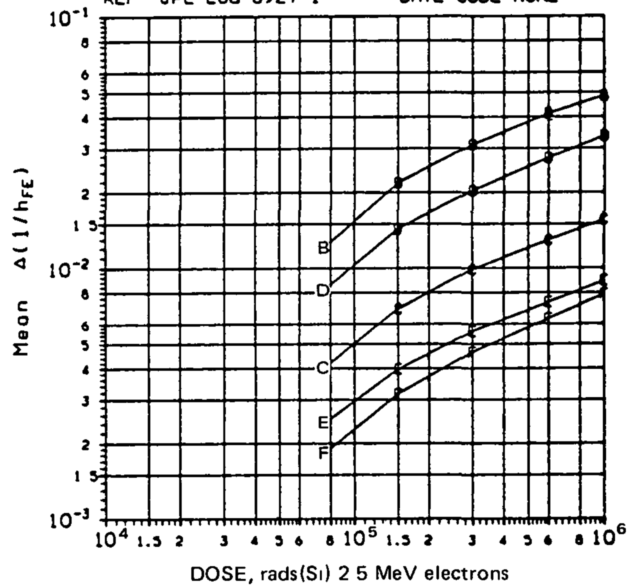
DOSE, rads(Si) 2.5 MeV electrons

(1)ICER IN NA,VCE=60V,RBE=4OHMS: VS DOSE

TABLE OF NORMAL STANDARD DEVIATIONS	
CURVE	DOSE, kilorads(Si) 75 150 300 600
A	126.7 864 3 3048. 4680.

INITIAL MEAN VALUE ICER(A) = $1.74X10^{+0}$

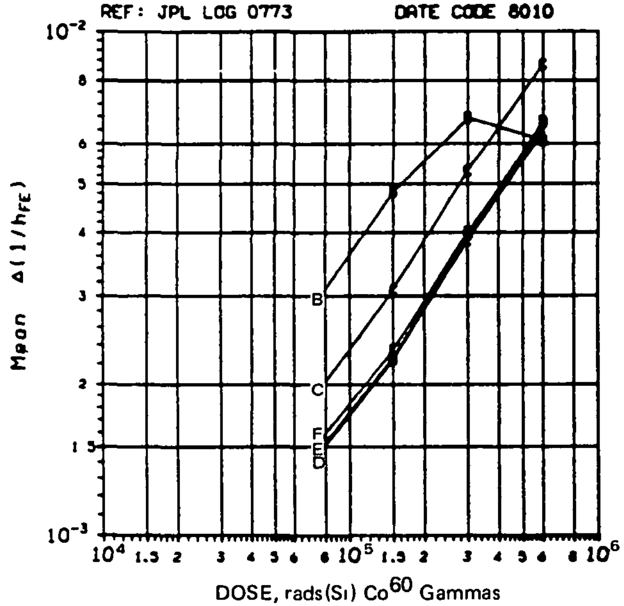
DEVICE TYPE: MQ2219 TRANSISTOR QUAD
MFG. MOT 8 DEVICES TEST DATE 12-21-82
REF· JPL LOG 0927-1 DATE CODE NONE



$\Delta(1/h_{FE})$ VS DOSE

TABLE OF NORMAL STANDARD DEVIATIONS						
CURVE	I_C (mA)	V_{CE} (v)	DOSE, kilorads(Si) 75	150	300	600
B	2.000	100	.0012	0013	0020	0020
C	2.000	2.40	.0010	.0013	0017	0017
D	10 00	100	0006	0007	0011	0014
E	10.00	2 40	0005	.0006	.0008	.0008
F	40 00	250	0003	0003	0005	0005

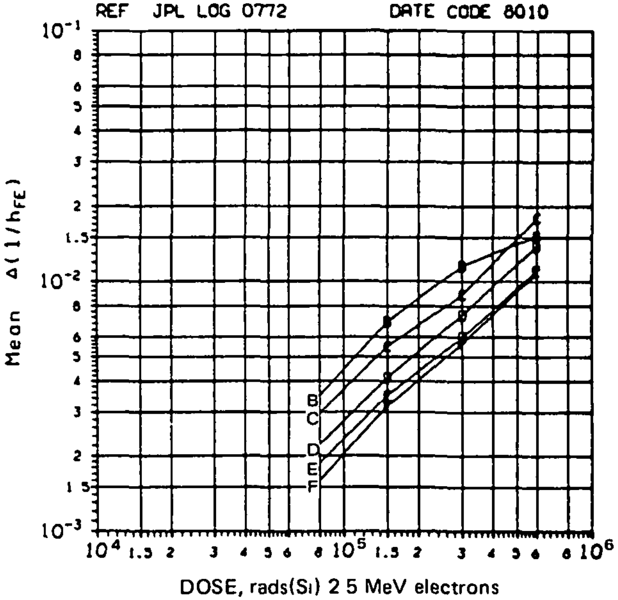
DEVICE TYPE: SDT3323 PNP POWER TRANSISTOR
MFG: SOD 8 DEVICES TEST DATE 7-17-81
REF: JPL LOG 0773 DATE CODE 8010



$\Delta(1/h_{FE})$ VS DOSE

TABLE OF NORMAL STANDARD DEVIATIONS						
CURVE	I_C (mA)	V_{CE} (v)	DOSE, kilorads(Si) 75	150	300	600
B	1.000	5.00	.0007	.0011	.0020	.0048
C	10.00	2.00	.0004	.0006	.0010	.0015
D	100.0	2.00	.0003	.0005	.0008	.0012
E	1000.	2.00	.0004	.0006	.0009	.0012
F	2000.	5.00	.0004	.0006	.0009	.0013

DEVICE TYPE SDT3323 PNP POWER TRANSISTOR
MFG. SOD 8 DEVICES TEST DATE 9-22-81
REF JPL LOG 0772 DATE CODE 8010



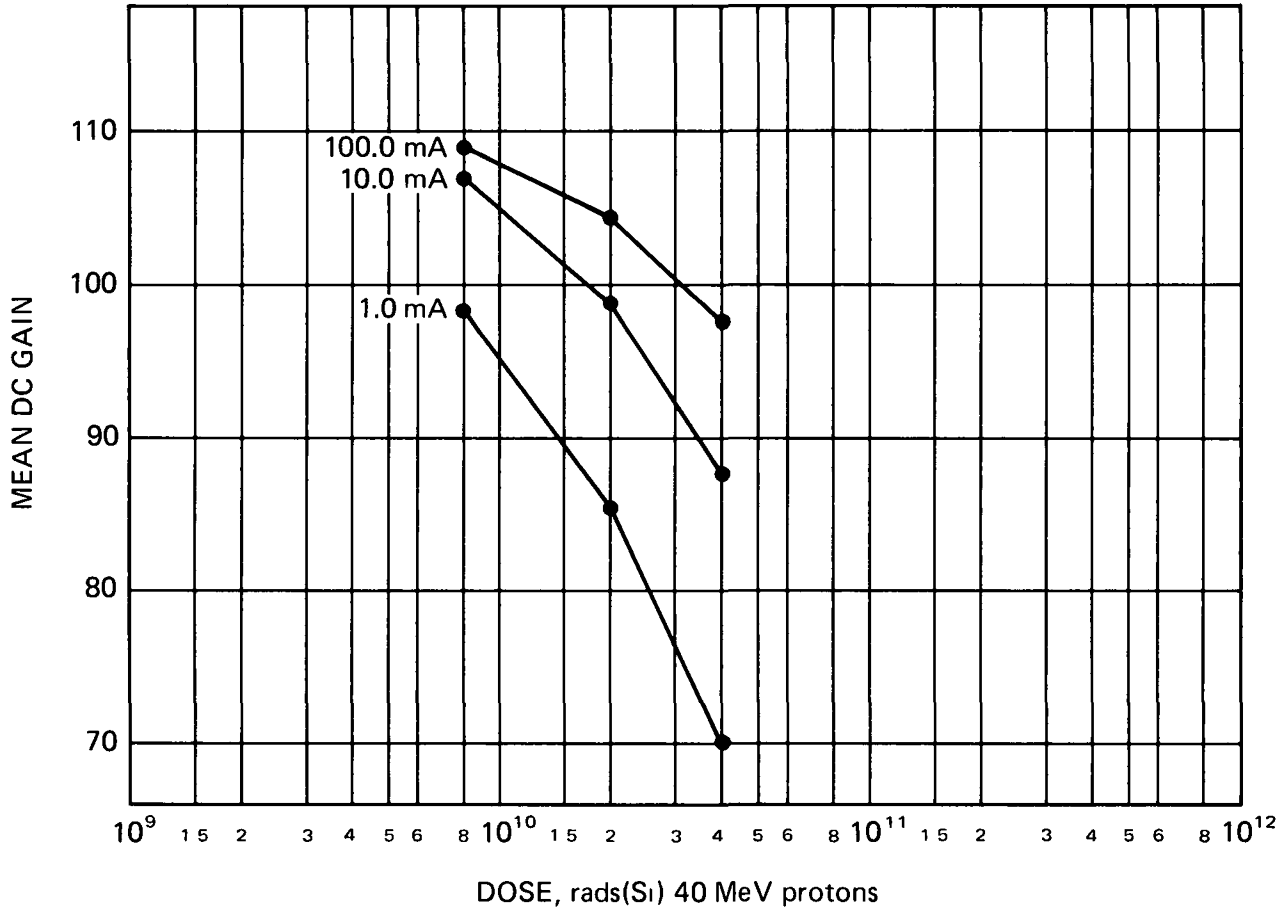
$\Delta(1/h_{FE})$ VS DOSE

TABLE OF NORMAL STANDARD DEVIATIONS						
CURVE	I_C (mA)	V_{CE} (v)	DOSE, kilorads(Si) 75	150	300	600
B	1.000	5.00	0003	0006	0023	.0073
C	10.00	2 00	0002	.0005	0028	.0015
D	100.0	2.00	0002	0003	0005	.0009
E	1000.	2.00	.0002	.0004	.0004	.0006
F	2000	5 00	.0007	0008	.0009	.0014

DEVICE TYPE. SDT3323 NPN POWER TRANSISTOR

MFG: SOD 6 DEVICES TEST DATE: 7/15/81

REF: JPL LOG 0761 DATE CODE. NONE



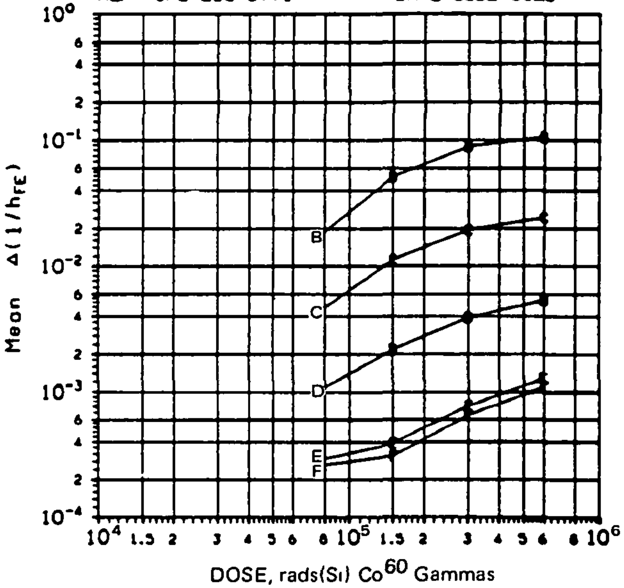
DC GAIN vs DOSE

INITIAL MEAN DC GAIN VALUE = 107 5 @ 1.0 mA

111.7 @ 10.0 mA

110.5 @ 100.0 mA

DEVICE TYPE: SDT 3423 NPN POWER TRANSISTOR
MFG: SOD 8 DEVICES TEST DATE 7-16-81
REF· JPL LOG 0771 DATE CODE 8123

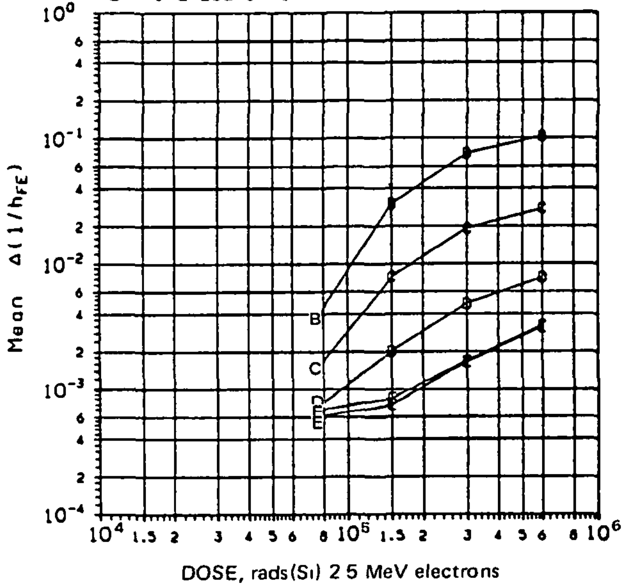


DOSE, rads(Si) Co^{60} Gammas

$\Delta(1/h_{FE})$ VS DOSE

TABLE OF NORMAL STANDARD DEVIATIONS						
CURVE	I_c (mA)	V_{CE} (v)	DOSE, kilorads(Si) 75	150	300	600
B	1.000	5.00	0213	.0370	.0539	.0686
C	10.00	2.00	.0044	.0079	.0123	.0165
D	100.0	2.00	.0007	.0013	.0020	.0028
E	1000.	2.00	.0002	0003	.0004	.0005
F	2000.	5.00	.0003	.0003	.0003	.0004

DEVICE TYPE: SDT 3423 NPN POWER TRANSISTOR
MFG. SOD 8 DEVICES TEST DATE 10-26-81
REF. JPL LOG 0770 DATE CODE NONE



DOSE, rads(Si) 2 5 MeV electrons

$\Delta(1/h_{FE})$ VS DOSE

TABLE OF NORMAL STANDARD DEVIATIONS						
CURVE	I_c (mA)	V_{CE} (v)	DOSE, kilorads(Si) 75	150	300	600
B	1.000	5.00	.0022	.0240	.0641	0830
C	10.00	2.00	.0007	.0049	.0141	.0192
D	100 0	2.00	0004	0009	.0027	.0040
E	1000.	2.00	0002	.0002	.0004	.0007
F	2000.	5.00	0002	0002	.0003	0005

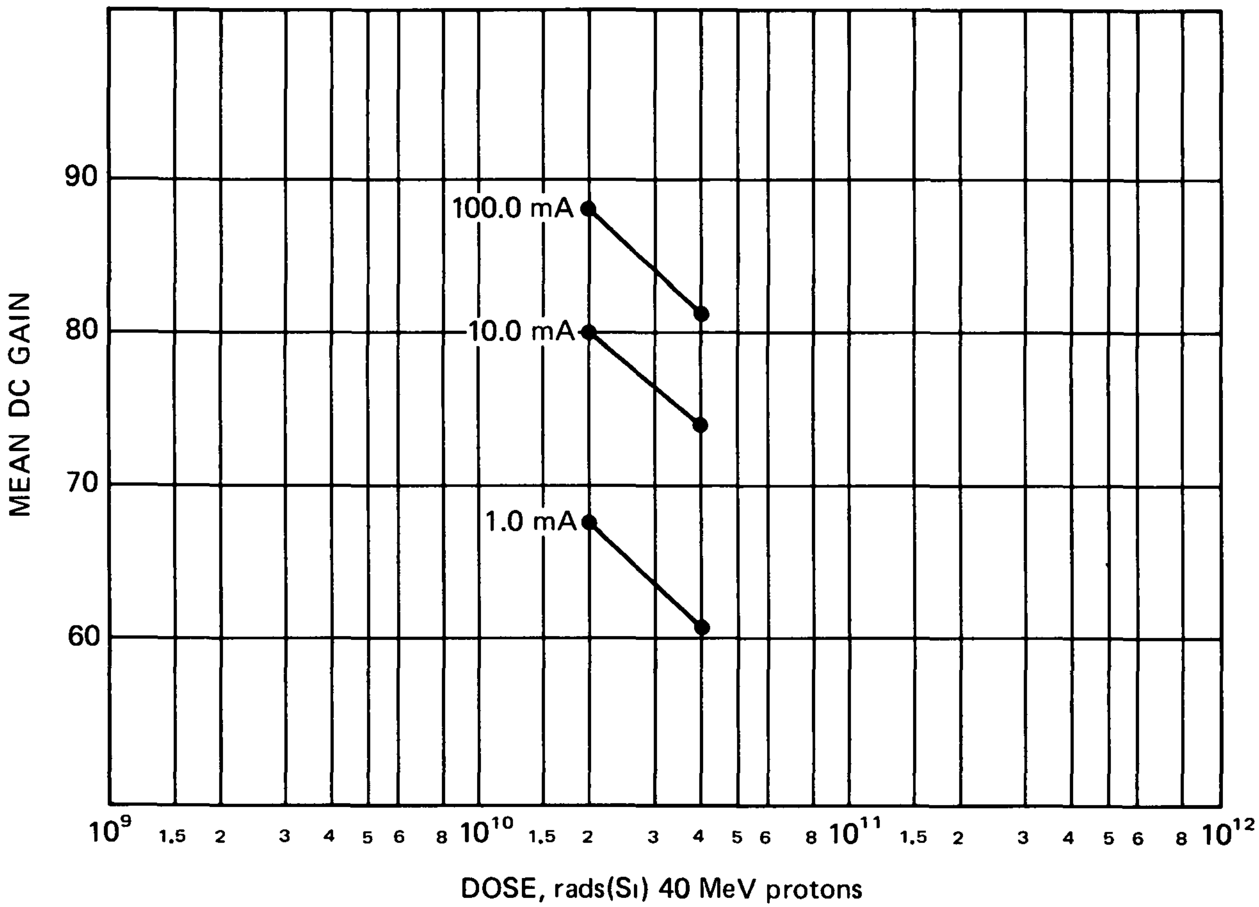
DEVICE TYPE: SDT 3423

MFG: SOD 6 DEVICES

REF: JPL LOG 0768

TEST DATE: 7/16/81

DATE CODE: NONE



DC GAIN vs DOSE

INITIAL MEAN DC GAIN VALUE = 72.2 @ 1.0 mA

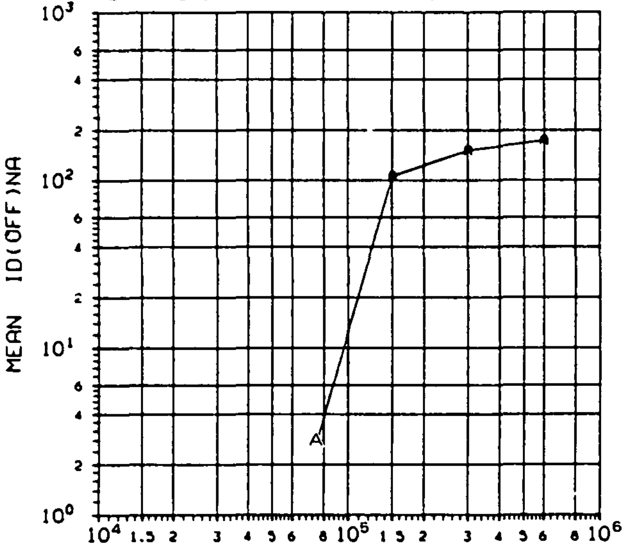
83.8 @ 10.0 mA

91.8 @ 100.0 mA

D. FIELD EFFECT TRANSISTORS (FETs)

Junction-gate field effect transistors (JFETs) have a considerably higher tolerance to radiation-induced bulk damage than bipolar transistors since they are majority-carrier devices. Therefore, most tests were conducted using electron irradiation. Key parameters plotted as a function of dose include I_{GSS}, I_{DSS}, V_{GS}, transconductance, noise voltage, and I_D (off). (See Appendix B.)

DEVICE TYPE 2N4338 N-CHAN JFET
MFG: SIL 3 DEVICES TEST DATE 1-8-82
REF JPL LOG 0800 DATE CODE 8145



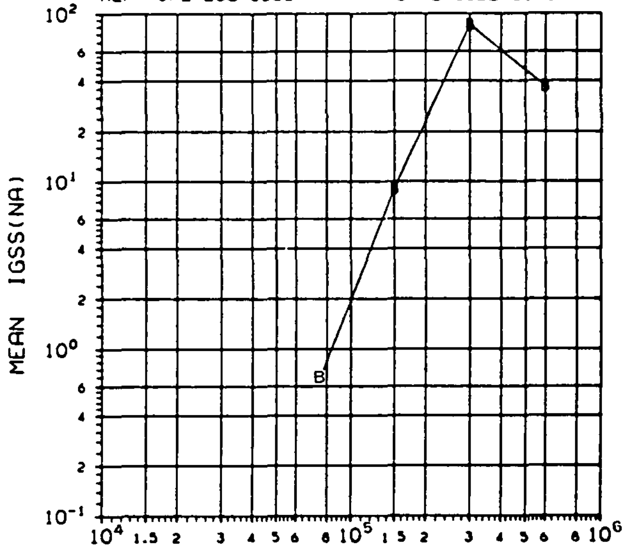
DOSE, rads(Si) 2.5 MeV electrons

(1)ID OFF (VDS=12V,VGS=-5V) IN NA: VS DOSE

TABLE OF NORMAL STANDARD DEVIATIONS				
CURVE	DOSE, kilorads(Si)			
	75	150	300	600
A	.7769	14 47	19 97	23 50

INITIAL MEAN VALUE ID(OFF)NA = 4 30X10^{-2}

DEVICE TYPE 2N4338 N-CHAN JFET
MFG: SIL 3 DEVICES TEST DATE 1-8-82
REF JPL LOG 0800 DATE CODE 8145



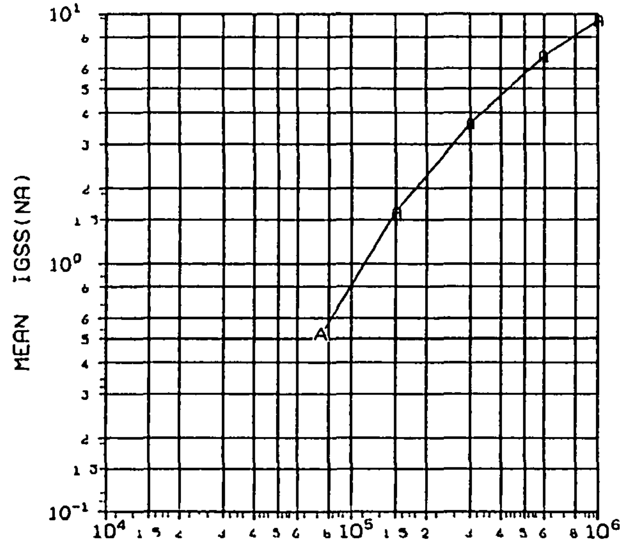
DOSE, rads(Si) 2.5 MeV electrons

(2)IGSS (VDS=0V,VGS=-12V) IN NA: VS DOSE

TABLE OF NORMAL STANDARD DEVIATIONS				
CURVE	DOSE, kilorads(Si)			
	75	150	300	600
B	1510	1.012	6.658	7.024

INITIAL MEAN VALUE IGSS(NA) = 1.28X10^{-2}

DEVICE TYPE 2N4391 N-JFET
MFG SIL 5 DEVICES TEST DATE 6-22-83
REF TPL LOG 1014 DATE CODE 8319

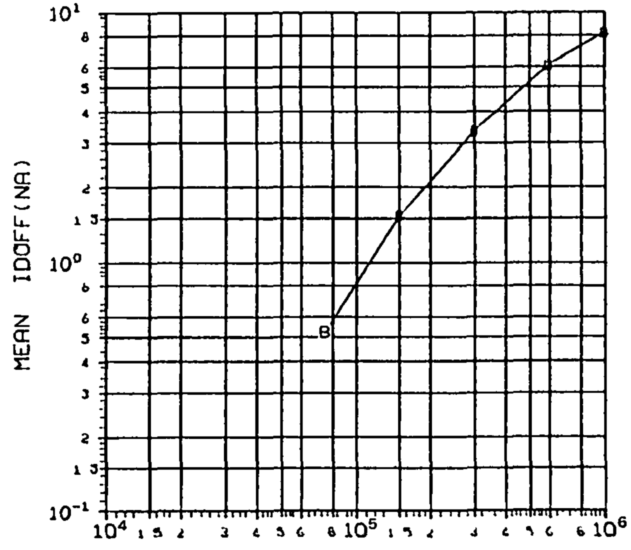


(1) IGSS (VDS=0, VGS=-10V) IN NA VS DOSE

TABLE OF NORMAL STANDARD DEVIATIONS					
CURVE	DOSE, kilorads(Si)				
	75	150	300	600	1000
A	0492	2526	5857	1 060	1 575

INITIAL MEAN VALUE IGSS(NA) = 5 22X10^{-2}

DEVICE TYPE · 2N4391 N-JFET
MFG SIL 5 DEVICES TEST DATE 6-22-83
REF TPL LOG 1014 DATE CODE 8319

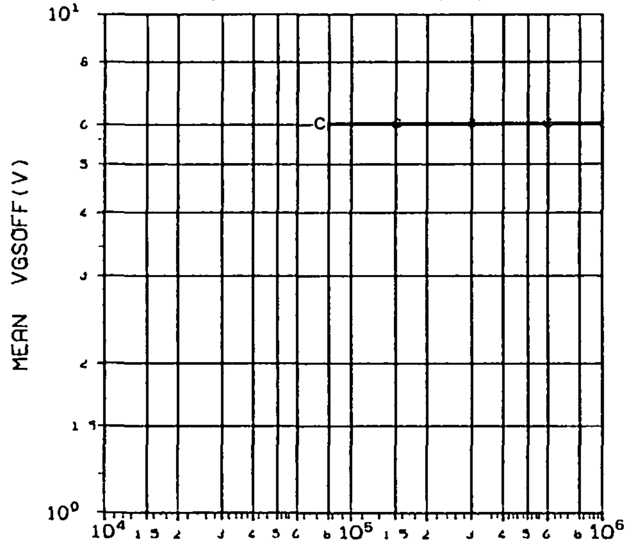


(2) ID OFF (VDS=10V, VGS=-10V) IN NA VS DOSE

TABLE OF NORMAL STANDARD DEVIATIONS					
CURVE	DOSE, kilorads(Si)				
	75	150	300	600	1000
B	0802	.2833	8961	1 839	2 431

INITIAL MEAN VALUE IDOFF(NA) = 5 20X10^{-2}

DEVICE TYPE 2N4391 N-JFET
MFG SIL 5 DEVICES TEST DATE 6-22-83
REF JPL LOG 1014 DATE CODE 8319

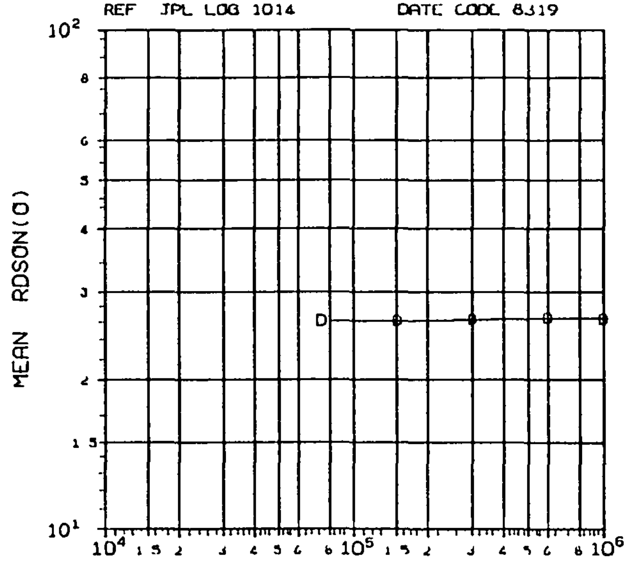


(3)VGSOFF (VDS=10V,ID=1NA) IN V VS DOSE

TABLE OF NORMAL STANDARD DEVIATIONS					
CURVE	DOSE, kilorads(Si)				
	75	150	300	600	1000
C	7736	7736	7702	7702	7712

INITIAL MEAN VALUE VGSOFF(V) = 6 07X10^{-0}

DEVICE TYPE 2N4391 N-JFET
MFG SIL 5 DEVICES TEST DATE 6-22-83
REF JPL LOG 1014 DATE CODE 8319

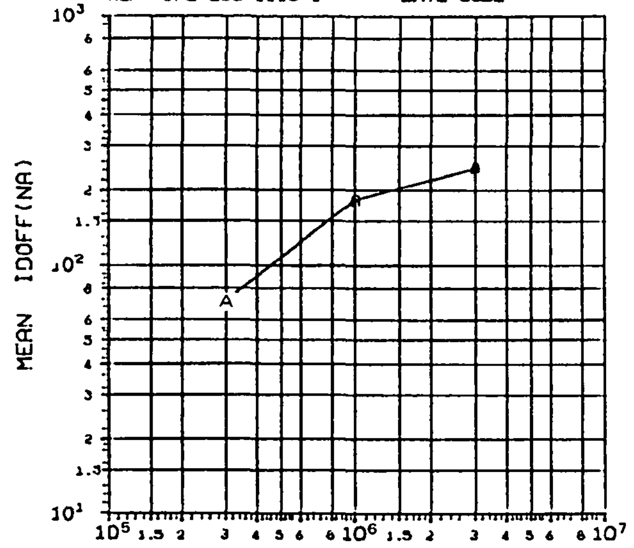


(4)RDS ON (VGS=0,ID=1MA) IN OHMS VS DOSE

TABLE OF NORMAL STANDARD DEVIATIONS					
CURVE	DOSE, kilorads(Si)				
	75	150	300	600	1000
D	2 413	2 416	2 384	2 606	2 462

INITIAL MEAN VALUE RDSON(O) = 2 55X10^{+1}

DEVICE TYPE: 2N4391 (N-JFET)
MFG MOT   6 DEVICES   TEST DATE 3-1-85
REF JPL LOG 1118-1   DATE CODE



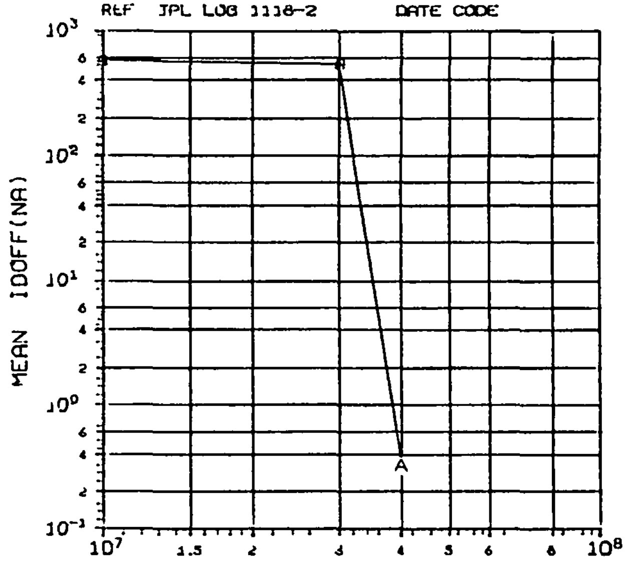
DOSE, rads(Si) 2.5 MeV electrons

(1)IDOFF (VDS=15V,VGS=-12V) IN NA VS DOSE

TABLE OF NORMAL STANDARD DEVIATIONS			
CURVE	DOSE, megarads(Si)		
	0.3	1.0	3.0
A	19.60	33.66	90 43

INITIAL MEAN VALUE IDOFF(NA) = $1.37\times10^{+1}$

DEVICE TYPE: 2N4391 (N-JFET)
MFG: MOT   6 DEVICES   TEST DATE 3-1-85
REF JPL LOG 1118-2   DATE CODE



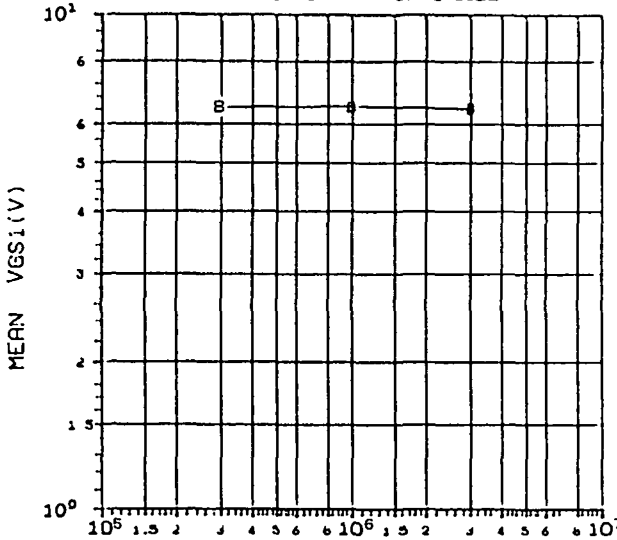
DOSE, rads(Si) 2.5 MeV electrons

(1)IDOFF VDS=15V,VGS=-12V) IN NA: VS DOSE

TABLE OF NORMAL STANDARD DEVIATIONS			
CURVE	DOSE, megarads(Si)		
	10.0	30.0	40 0
A	69 63	278 0	0773

INITIAL MEAN VALUE IDOFF(NA) = $1\ 37\times10^{+1}$

DEVICE TYPE: 2N4391 (N-JFET)
MFG: MOT 6 DEVICES TEST DATE 3-1-85
REF: JPL LOG 1118-1 DATE CODE



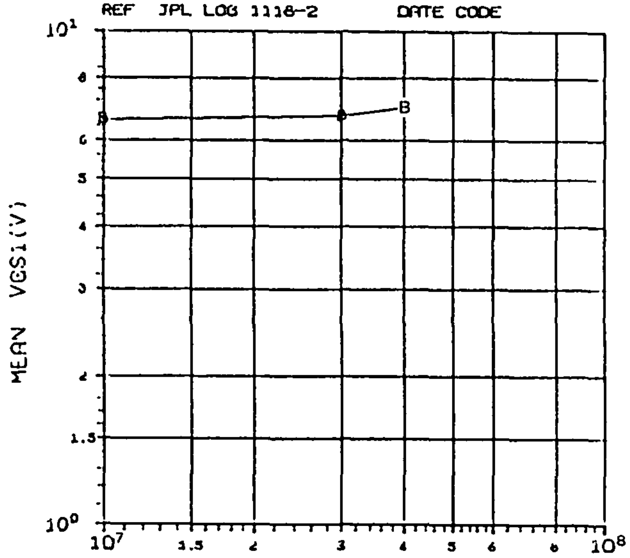
DOSE, rads(Si) 2.5 MeV electrons

(2)VGS1 (VDS=15V,IDS=1UA) IN V: VS DOSE

TABLE OF NORMAL STANDARD DEVIATIONS			
CURVE	DOSE, megarads(Si)		
	0.3	1.0	3.0
B	.5946	.6056	.7945

INITIAL MEAN VALUE VGS1(V) = $6.48 \times 10^{+0}$

DEVICE TYPE: 2N4391 (N-JFET)
MFG: MOT 6 DEVICES TEST DATE 3-1-85
REF JPL LOG 1118-2 DATE CODE



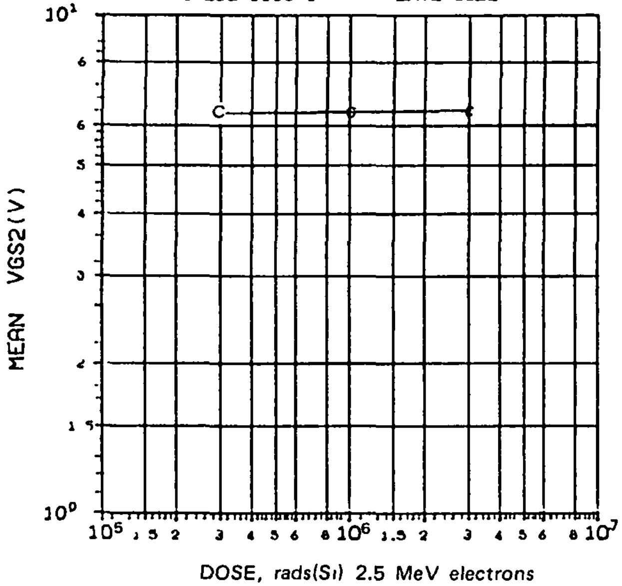
DOSE, rads(Si) 2.5 MeV electrons

(2)VGS1 VDS=15V,IDS=1UA) IN V. VS DOSE

TABLE OF NORMAL STANDARD DEVIATIONS			
CURVE	DOSE, megarads(Si)		
	10.0	30.0	40.0
B	.6174	.6861	.7062

INITIAL MEAN VALUE VGS1(V) = $6.48 \times 10^{+0}$

DEVICE TYPE· 2N4391 (N-JFET)
MFG· MOT 6 DEVICES TEST DATE 3-1-85
REF· JPL LOG 1118-1 DATE CODE

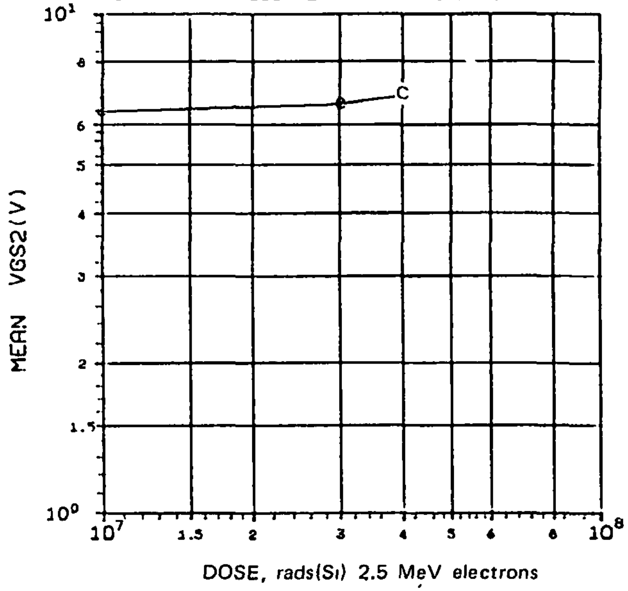


(3)VGS2 (VDS=15V,IDS=10UA) IN V· VS DOSE

TABLE OF NORMAL STANDARD DEVIATIONS			
CURVE	DOSE, megarads(Si)		
	0 3	1 0	3.0
C	5897	5932	.5977

INITIAL MEAN VALUE VGS2(V) = $6.36X10^{+0}$

DEVICE TYPE· 2N4391 (N-JFET)
MFG· MOT 6 DEVICES TEST DATE 3-1-85
REF JPL LOG 1118-2 DATE CODE



(3)VGS2 VDS=15V,IDS=10UA) IN V· VS DOSE

TABLE OF NORMAL STANDARD DEVIATIONS			
CURVE	DOSE, megarads(Si)		
	10.0	30.0	40 0
C	.6162	6830	.7007

INITIAL MEAN VALUE VGS2(V) = $6.36X10^{+0}$

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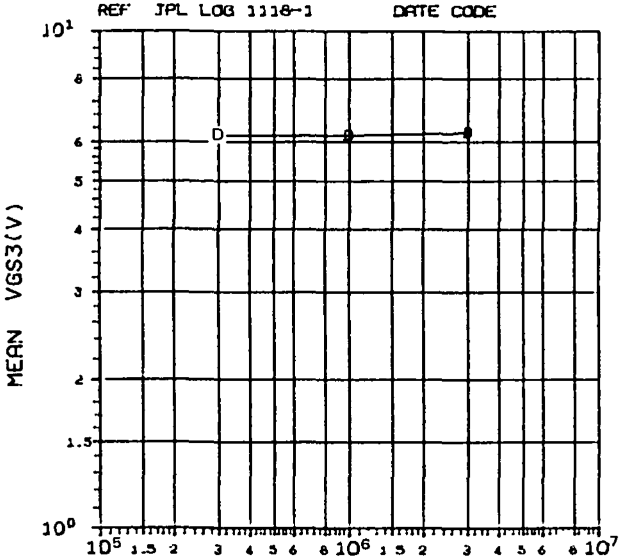
DEVICE TYPE · 2N4391 (N-JFET)
MFG · MOT   6 DEVICES   TEST DATE 3-1-85
REF · JPL LOG 1118-1   DATE CODE



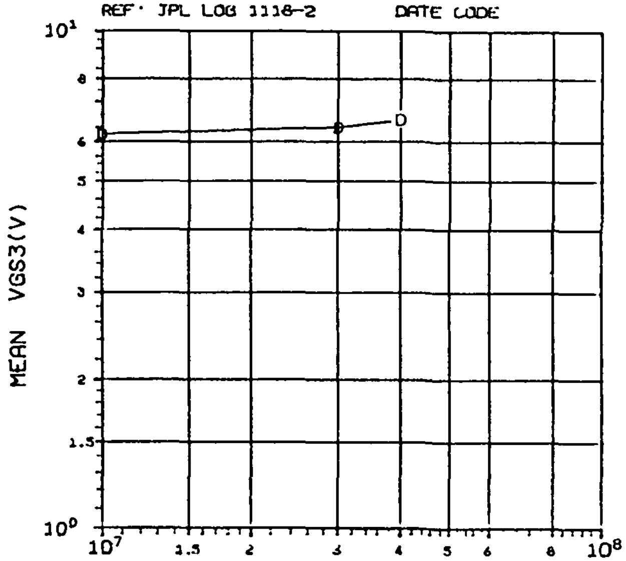
DOSE, rads(Si) 2.5 MeV electrons

(4)VGS3 (VDS=15V,IDS=100UA)IN V · VS DOSE

TABLE OF NORMAL STANDARD DEVIATIONS			
CURVE	DOSE, megarads(Si)		
	0.3	1.0	3.0
D	.5897	.5928	.5163

INITIAL MEAN VALUE VGS3(V) = $6.18X10^{+0}$

DEVICE TYPE 2N4391 (N-JFET)
MFG · MOT   6 DEVICES   TEST DATE 3-1-85
REF · JPL LOG 1118-2   DATE CODE



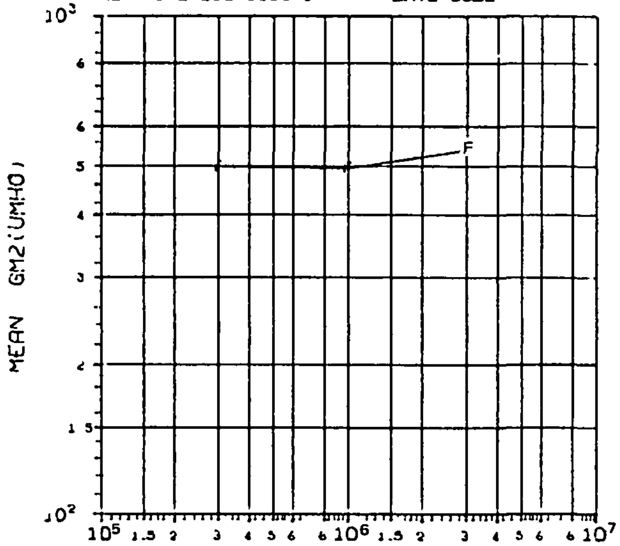
DOSE, rads(Si) 2.5 MeV electrons

(4)VGS3 VDS=15V,IDS=100UA)IN V VS DOSE

TABLE OF NORMAL STANDARD DEVIATIONS			
CURVE	DOSE, megarads(Si)		
	10.0	30.0	40.0
D	6186	.6835	.7016

INITIAL MEAN VALUE VGS3(V) = $6.18X10^{+0}$

DEVICE TYPE: 2N4391 (N-JFET)
MFG: MOT 6 DEVICES TEST DATE 3-1-85
REF: JPL LOG 1118-1 DATE CODE



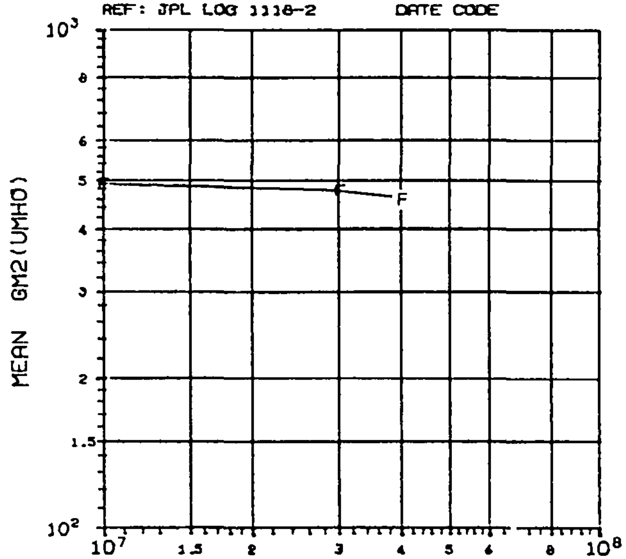
DOSE, rads(Si) 2.5 MeV electrons

(6)GM2(VDS=15V,IDS=10TO100UA,INUMHO VS DOSE

TABLE OF NORMAL STANDARD DEVIATIONS			
CURVE	DOSE, megarads(Si)		
	0.3	1.0	3.0
F	60.77	59.52	116.0

INITIAL MEAN VALUE GM2(UMHO) = $5.06 \times 10^{+2}$

DEVICE TYPE: 2N4391 (N-JFET)
MFG: MOT 6 DEVICES TEST DATE 3-1-85
REF: JPL LOG 1118-2 DATE CODE



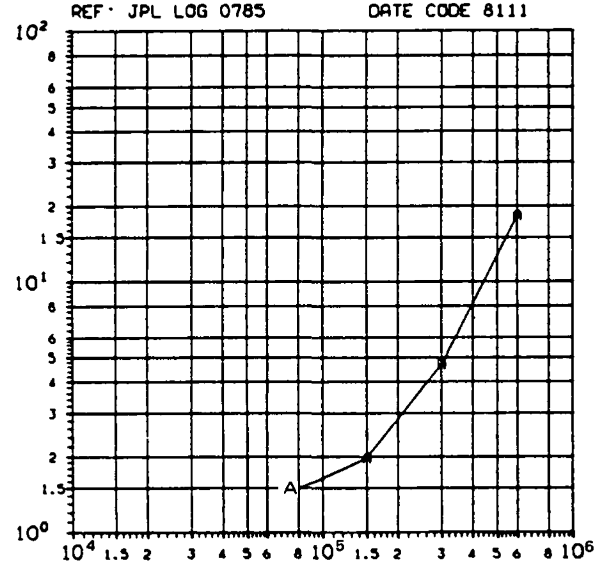
DOSE, rads(Si) 2.5 MeV electrons

(6)GM2(VDS=15V,IDS=10TO100UA,INUMHO VS DOSE

TABLE OF NORMAL STANDARD DEVIATIONS			
CURVE	DOSE, megarads(Si)		
	10.0	30.0	40.0
F	62.87	60.89	59.21

INITIAL MEAN VALUE GM2(UMHO) = $5.06 \times 10^{+2}$

DEVICE TYPE: 2N4867 N-JFET
MFG: SIL 3 DEVICES TEST DATE 9-23-81
REF· JPL LOG 0785 DATE CODE 8111

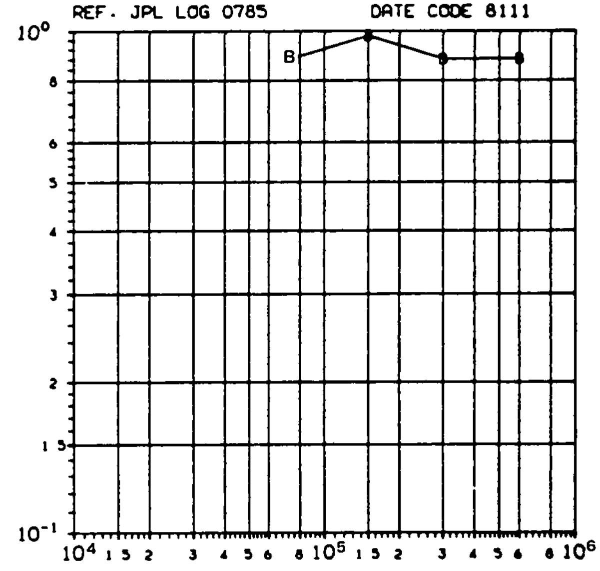


(1)IGSS (VDS=0,VGS=-10V) IN NA: VS DOSE

TABLE OF NORMAL STANDARD DEVIATIONS				
CURVE	DOSE, kilorads(Si)			
	75	150	300	600
A	1.650	1.545	1.132	5.747

INITIAL MEAN VALUE IGSS(NA) = $5.50X10^{+0}$

DEVICE TYPE· 2N4867 N-JFET
MFG: SIL 3 DEVICES TEST DATE 9-23-81
REF. JPL LOG 0785 DATE CODE 8111

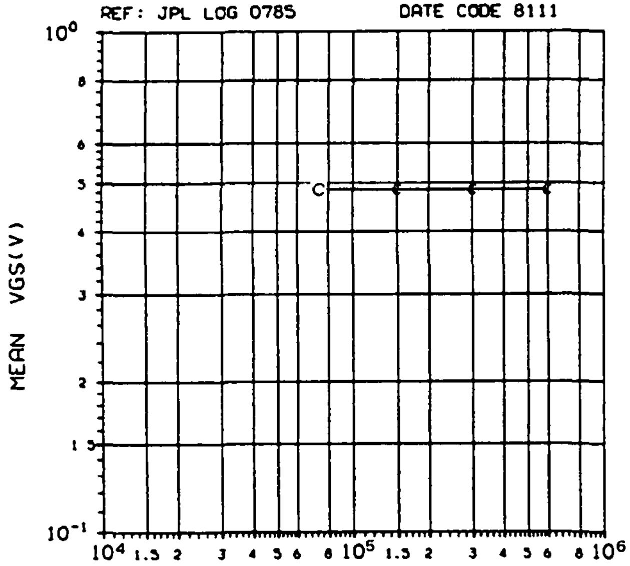


(2)IDSS (VDS=10V,VGS=0) IN MA: VS DOSE

TABLE OF NORMAL STANDARD DEVIATIONS				
CURVE	DOSE, kilorads(Si)			
	75	150	300	600
B	1291	0671	.1332	.1349

INITIAL MEAN VALUE IDSS(MA) = $8.84X10^{-1}$

DEVICE TYPE: 2N4867 N-JFET
MFG. SIL 3 DEVICES TEST DATE 9-23-81
REF: JPL LOG 0785 DATE CODE 8111



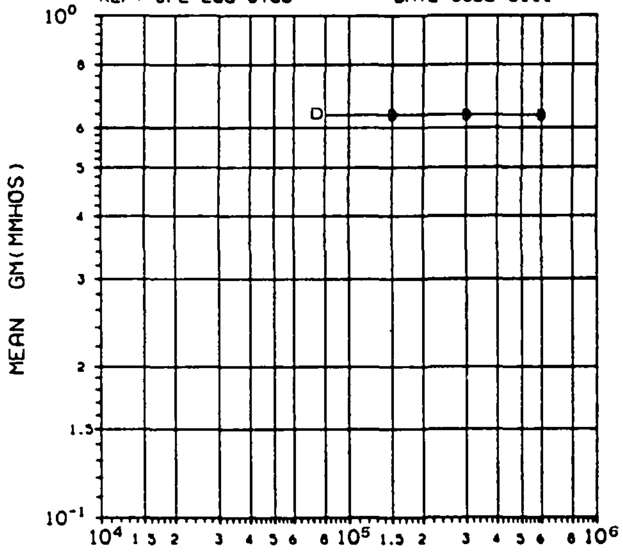
DOSE, rads(Si) Co^{60} Gammas

(3)VGS (VDS=10V, ID=300UA) IN VOLTS: VS DOSE

TABLE OF NORMAL STANDARD DEVIATIONS				
CURVE	DOSE, kilorads(Si)			
	75	150	300	600
C	0958	.0958	0948	.0955

INITIAL MEAN VALUE VGS(V) = 4.85×10^{-1}

DEVICE TYPE 2N4867 N-JFET
MFG: SIL 3 DEVICES TEST DATE 9-23-81
REF. JPL LOG 0785 DATE CODE 8111



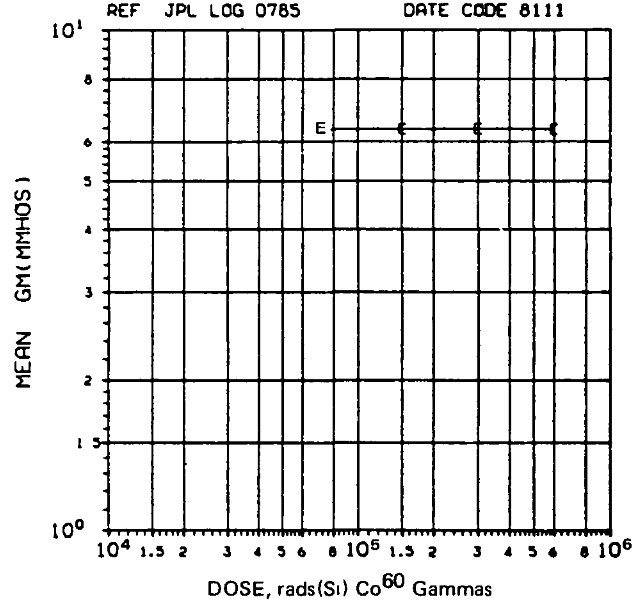
DOSE, rads(Si) Co^{60} Gammas

(4)GM1 (VDS=10V, ID=300UA) IN MMHOS. VS DOSE

TABLE OF NORMAL STANDARD DEVIATIONS				
CURVE	DOSE, kilorads(Si)			
	75	150	300	600
D	.1353	.1359	1343	.1348

INITIAL MEAN VALUE GM(MMHOS) = 6.36×10^{-1}

DEVICE TYPE 2N4867 N-JFET
MFG: SIL 3 DEVICES TEST DATE 9-23-81
REF JPL LOG 0785 DATE CODE 8111



(5)GM2 (VDS=10V,ID=3.0MA) IN MMHOS VS DOSE

TABLE OF NORMAL STANDARD DEVIATIONS				
CURVE	DOSE, kilorads(Si)			
	75	150	300	600
E	1.353	1.359	1.336	1.348

INITIAL MEAN VALUE GM(MMHOS) = $6.36X10^{-0}$

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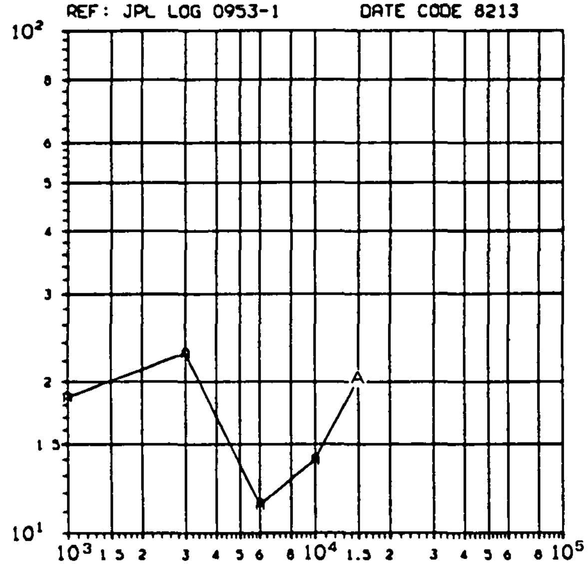
DEVICE TYPE· IRF150 HEXFET
MFG. INR 3 DEVICES TEST DATE 12-17-82
REF: JPL LOG 0953-1 DATE CODE 8213



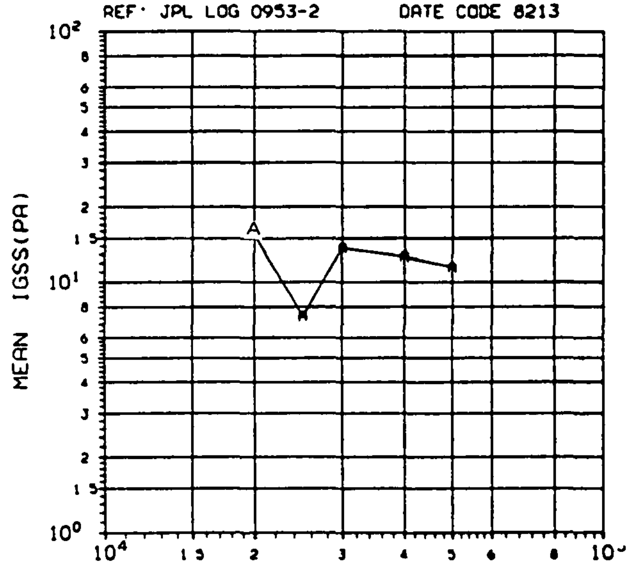
DOSE, rads(Si) Co^{60} Gammas

(1) IGSS (VGS=15V, VDS=0) IN PA: VS DOSE

TABLE OF NORMAL STANDARD DEVIATIONS					
CURVE	DOSE, kilorads(Si)				
	1	3	6	10	15
A	5 859	5 965	11 81	6.083	10.69

INITIAL MEAN VALUE IGSS(PA) = $4.37X10^{+0}$

DEVICE TYPE: IRF150 HEXFET
MFG. INR 3 DEVICES TEST DATE 12-17-82
REF· JPL LOG 0953-2 DATE CODE 8213



DOSE, rads(Si) Co^{60} Gammas

(1) IGSS (VGS=15V, VDS=0) IN PA. VS DOSE

TABLE OF NORMAL STANDARD DEVIATIONS					
CURVE	DOSE, kilorads(Si)				
	20	25	30	40	50
A	7 365	3.512	9 177	4 509	7 858

INITIAL MEAN VALUE IGSS(PA) = $4.37X10^{+0}$

RADIATION TESTS

LOG. 797 IRF-150

MFG INR

Total Dose (Krads)	I_{DSS} (Leakage Current)			
	S/N AD01	S/N AD02	S/N AD03	S/N AD04
0	.778 uA	.774 uA	.28 NA	.776 uA
1	.778 "	.778 "		.778 "
3	.779 "	.779 "		.779 "
6	.784 "	.784 "		.779 "
10	.780 "	.790 "		.779 "
15	.826 "	.871 "		.780 "
20	1.13 "	1.91 "		.792 "
25	4.44 "	15.0 "		.862 "
30	20.0 "	86.0 "		1.50 "
40	309.0 "	782.0 "		12.3 "
50	1.14 MA	3.82 MA		90.0 "
75	250.0 uA	15.4 "		.80 MA
150	22.8 MA	61.8 "		.250 uA
300	230.0 "	115.0 "		13.8 MA

Conditions. V_{DS} = 39 V

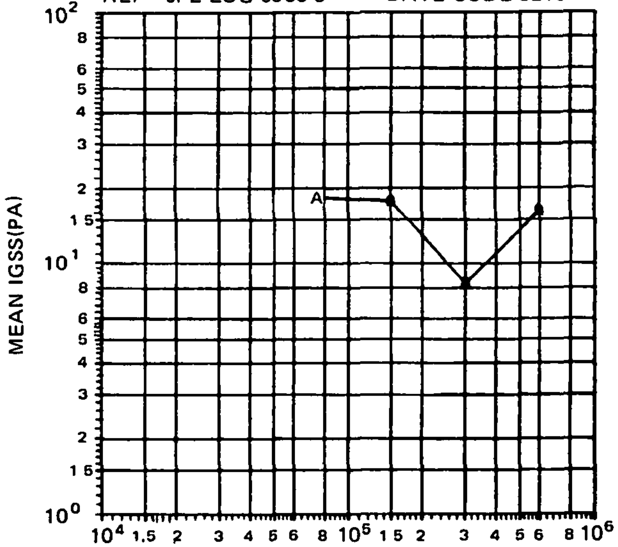
RADIATION TESTS

LOG 797 IRF-150

MFG INR

Total Dose (Krads)	$R_{D(ON)}$ CONDITIONS ID = 2A			
	S/N AD01	S/N AD02	S/N AD03	S/N AD04
0	.038 ohms	.042 ohms	.045 ohms	.046 ohms
1	.040 "	.044 "	.064 "	.046 "
3	.041 "	.044 "	.044 "	.047 "
6	.040 "	.045 "	.044 "	.047 "
10	.040 "	.044 "	.044 "	.046 "
15	.041 "	.044 "	.043 "	.046 "
20	.038 "	.043 "	.043 "	.045 "
25	.038 "	.043 "	.042 "	.045 "
30	.038 "	.043 "	.042 "	.045 "
40	.038 "	.042 "	.041 "	.044 "
50	.038 "	.042 "	.041 "	.045 "
75	.067 "	.043 "	.041 "	.044 "
150	.068 "	.043 "	.041 "	.044 "
300	.071 "	.046 "	.042 "	.045 "

DEVICE TYPE IRF150 HEXFET
MFG INR 3 DEVICES TEST DATE 12-17-82
REF JPL LOG 0953-3 DATE CODE 8213



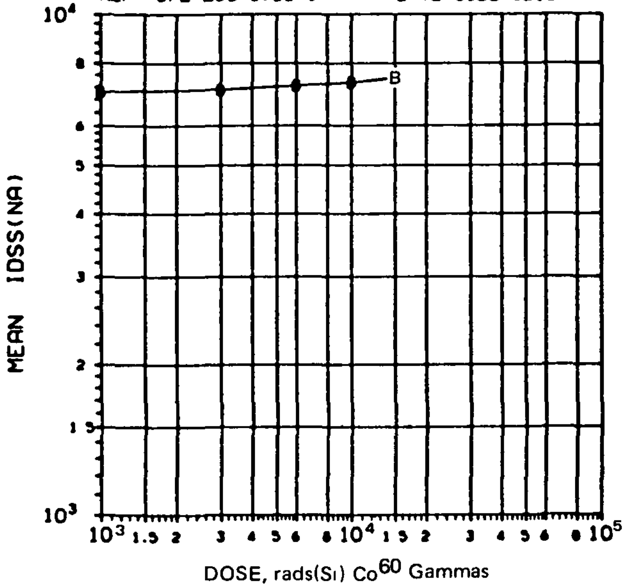
DOSE, rads(Si) Co^{60} Gammas

(1) IGSS (VGS=15V, VDS=0) IN PA vs DOSE

TABLE OF NORMAL STANDARD DEVIATIONS				
CURVE	DOSE, kilorads(Si)			
	75	150	300	600
A	16 07	4.509	2 517	11 19

INITIAL MEAN VALUE IGSS(PA) = $4.37 \times 10^{+0}$

DEVICE TYPE: IRF150 HEXFET
MFG: INR 3 DEVICES TEST DATE 12-17-82
REF: JPL LOG 0953-1 DATE CODE 8213

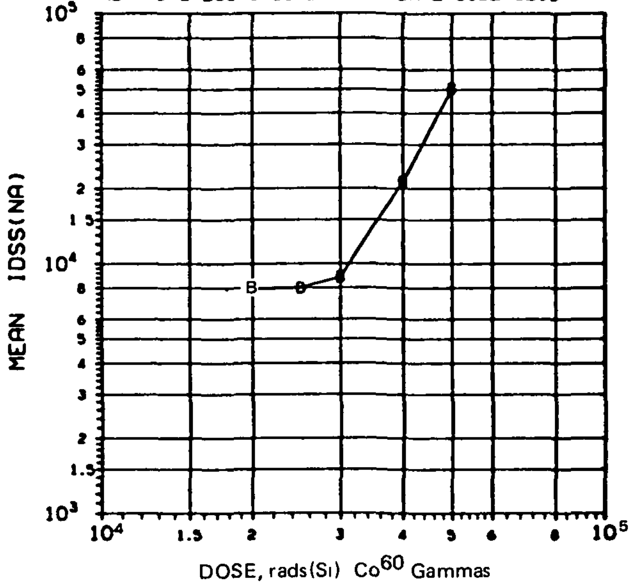


(2) IDSS (VDS=30V,VGS=0) IN NA: VS DOSE

TABLE OF NORMAL STANDARD DEVIATIONS					
CURVE	DOSE, kilorads(Si)				
	1	3	6	10	15
B	*****	*****	*****	*****	*****

INITIAL MEAN VALUE IDSS(NA) = $7.03X10^{+3}$

DEVICE TYPE: IRF150 HEXFET
MFG: INR 3 DEVICES TEST DATE 12-17-82
REF: JPL LOG 0953-2 DATE CODE 8213

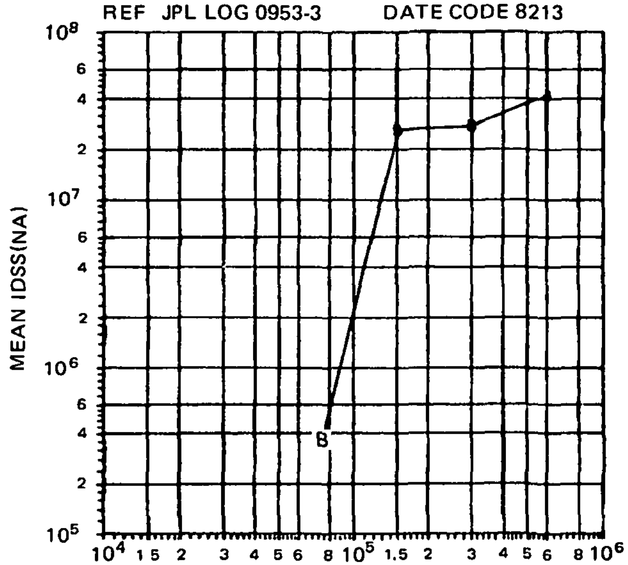


(2) IDSS (VDS=30V,VGS=0) IN NA: VS DOSE

TABLE OF NORMAL STANDARD DEVIATIONS					
CURVE	DOSE, kilorads(Si)				
	20	25	30	40	50
B	*****	*****	*****	*****	*****

INITIAL MEAN VALUE IDSS(NA) = $7.03X10^{+3}$

DEVICE TYPE IRF150 HEXFET
MFG INR 3 DEVICES TEST DATE 12-17-82
REF JPL LOG 0953-3 DATE CODE 8213



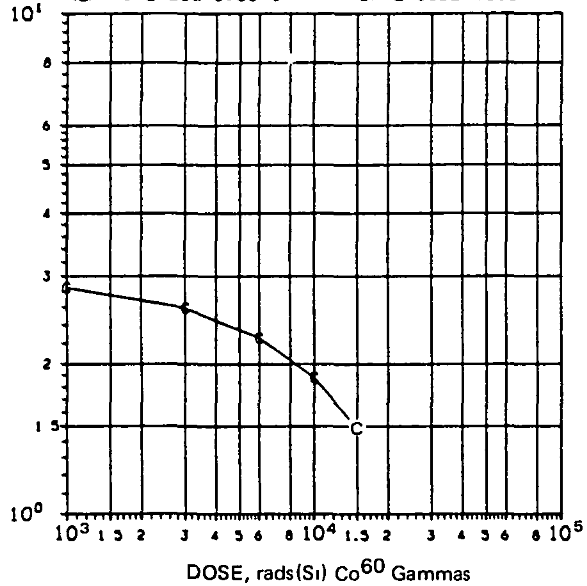
DOSE, rads(Si) Co^{60} Gammas

(2) IDSS (VDS=30V, VGS=0) IN NA vs DOSE

TABLE OF NORMAL STANDARD DEVIATIONS				
CURVE	DOSE, kilorads(Si)			
	75	150	300	600
B	*****	*****	*****	*****

INITIAL MEAN VALUE 1DSS(NA) = $7.03 \times 10^{+3}$

DEVICE TYPE: IRF150 HEXFET
MFG: INR 3 DEVICES TEST DATE 12-17-82
REF: JPL LOG 0953-1 DATE CODE 8213

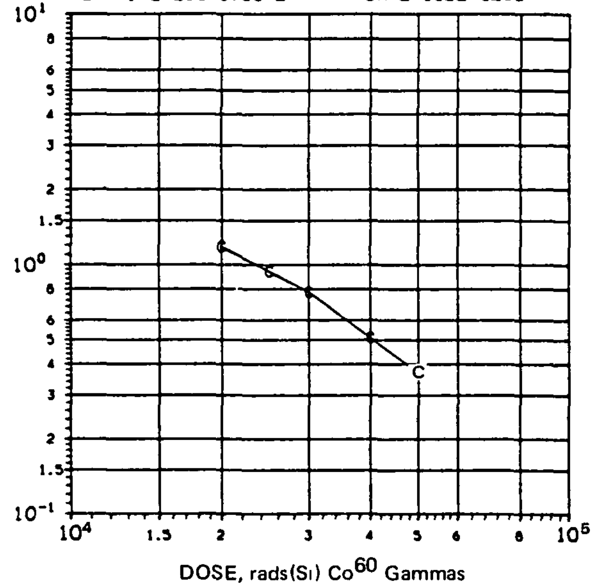


(3) VGS1 (VDS=15V, IDD=1MA) IN VOLT VS DOSE

TABLE OF NORMAL STANDARD DEVIATIONS					
CURVE	DOSE, kilorads(Si)				
	1	3	6	10	15
C	.2237	2C55	1973	.1801	.1589

INITIAL MEAN VALUE VGS1(V) = $2.98X10^{+0}$

DEVICE TYPE· IRF150 HEXFET
MFG: INR 3 DEVICES TEST DATE 12-17-82
REF: JPL LOG 0953-2 DATE CODE 8213

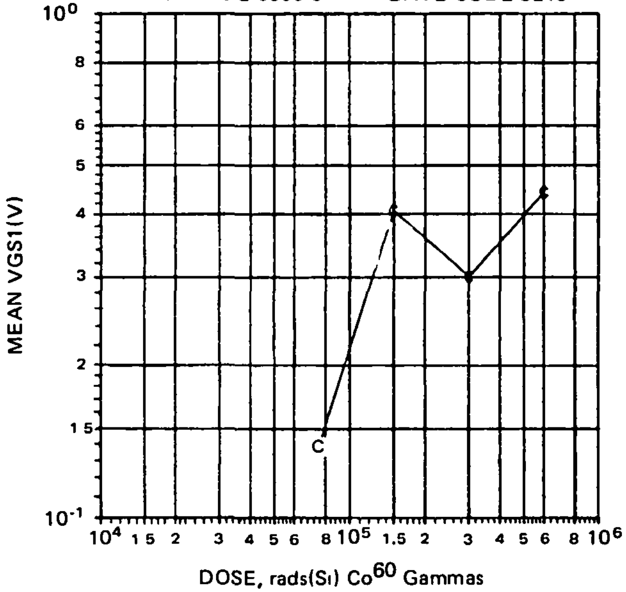


(3) VGS1 (VDS=15V, IDD=1MA) IN VOLT VS DOSE

TABLE OF NORMAL STANDARD DEVIATIONS					
CURVE	DOSE, kilorads(Si)				
	20	25	30	40	50
C	1386	.1389	.1112	.0881	.0715

INITIAL MEAN VALUE VGS1(V) = $2.98X10^{+0}$

DEVICE TYPE IRF150 HEXFET
MFG INR 3 DEVICES TEST DATE 12-17-82
REF JPL LOG 0953-3 DATE CODE 8213

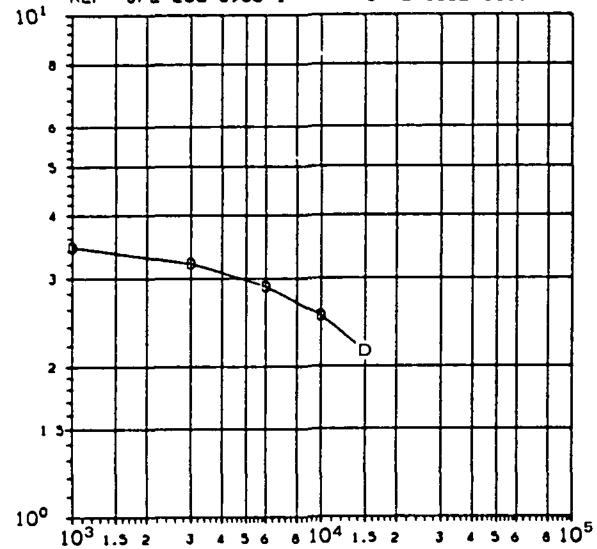


(3) VGS1 (VDS=15V,IDD=1mA) IN VOLT vs DOSE

TABLE OF NORMAL STANDARD DEVIATIONS				
CURVE	DOSE, kilorads(Si)			
	75	150	300	600
C	.0651	.0586	.1942	0827

INITIAL MEAN VALUE VGS1(V) = $2.98 \times 10^{+0}$

DEVICE TYPE. IRF150 HEXFET
MFG: INR 3 DEVICES TEST DATE 12-17-82
REF: JPL LOG 0953-1 DATE CODE 8213

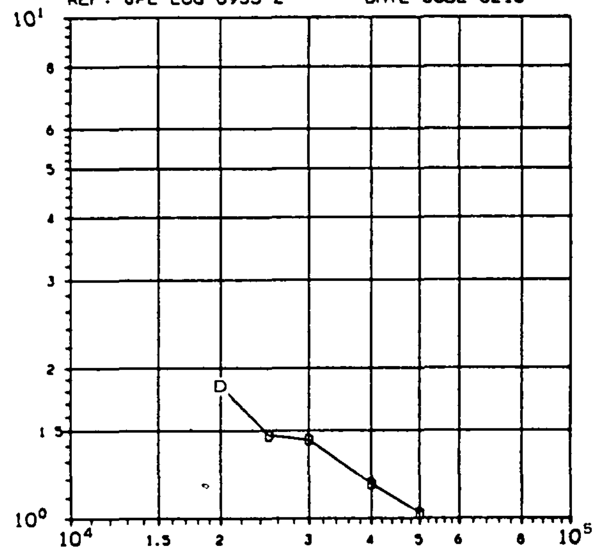


(4) VGS2 (VDS=15V, IDD=100MA) IN VOLT VS DOSE

TABLE OF NORMAL STANDARD DEVIATIONS					
CURVE	DOSE, kilorads(Si)				
	1	3	6	10	15
D	2551	2287	2155	2003	.1836

INITIAL MEAN VALUE VGS2(V) = 3.59X10+0

DEVICE TYPE: IRF150 HEXFET
MFG: INR 3 DEVICES TEST DATE 12-17-82
REF: JPL LOG 0953-2 DATE CODE 8213

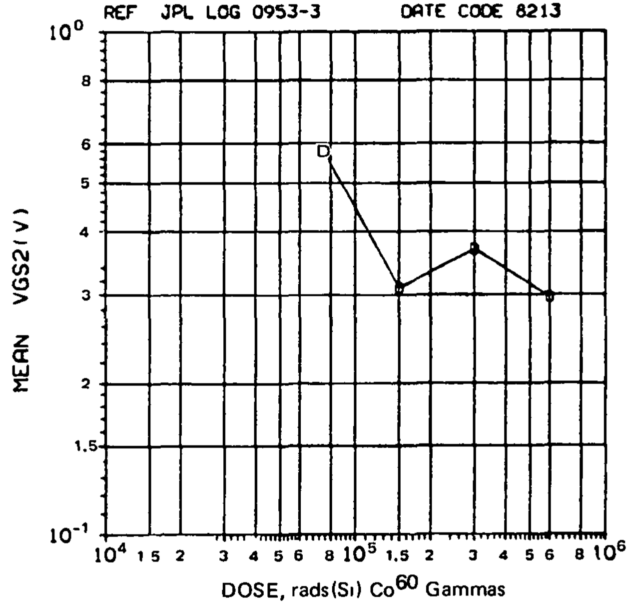


(4) VGS2 (VDS=15V, IDD=100MA) IN VOLT VS DOSE

TABLE OF NORMAL STANDARD DEVIATIONS					
CURVE	DOSE, kilorads(Si)				
	20	25	30	40	50
D	1607	1914	1380	.1250	.1079

INITIAL MEAN VALUE VGS2(V) = 3.59X10+0

DEVICE TYPE: IRF150 HEXFET
MFG: INR 3 DEVICES TEST DATE 12-17-82
REF JPL LOG 0953-3 DATE CODE 8213

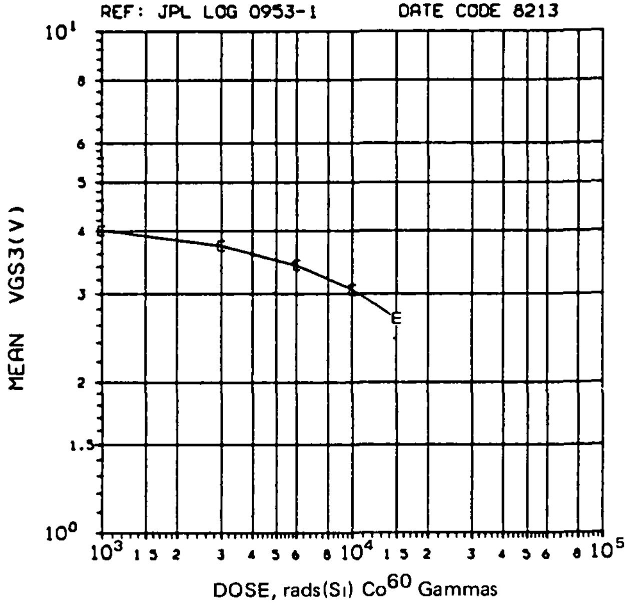


(4) VGS2 (VDS=15V, IDD=100MA) IN VOLT VS DOSE

TABLE OF NORMAL STANDARD DEVIATIONS				
CURVE	DOSE, kilorads(Si)			
	75	150	300	600
D	3595	1225	2377	.2091

INITIAL MEAN VALUE VGS2(V) = $3.59 \times 10^{+0}$

DEVICE TYPE· IRF150 HEXFET
MFG: INR 3 DEVICES TEST DATE 12-17-82
REF: JPL LOG 0953-1 DATE CODE 8213

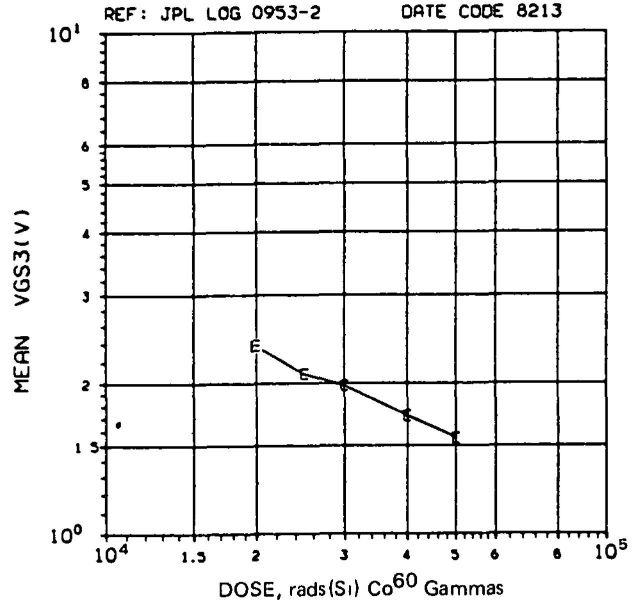


(5) VGS3 (VDS= 5V, IDD=500MA) IN VOLT VS DOSE

TABLE OF NORMAL STANDARD DEVIATIONS					
CURVE	DOSE, kilorads(Si)				
	1	3	6	10	15
E	3143	2663	2506	2318	2030

INITIAL MEAN VALUE VGS3(V) = $4.03X10^{+0}$

DEVICE TYPE. IRF150 HEXFET
MFG: INR 3 DEVICES TEST DATE 12-17-82
REF: JPL LOG 0953-2 DATE CODE 8213



(5) VGS3 (VDS= 5V, IDD=500MA) IN VOLT VS DOSE

TABLE OF NORMAL STANDARD DEVIATIONS					
CURVE	DOSE, kilorads(Si)				
	20	25	30	40	50
E	1914	1365	1662	.1752	.1401

INITIAL MEAN VALUE VGS3(V) = $4.03X10^{+0}$

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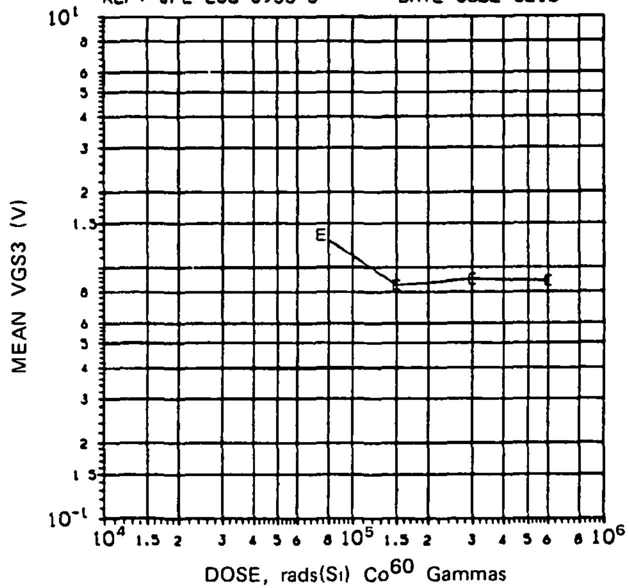
DEVICE TYPE. IRF150 HEXFET
MFG: INR 3 DEVICES TEST DATE 12-17-82
REF: JPL LOG 0953-3 DATE CODE 8213

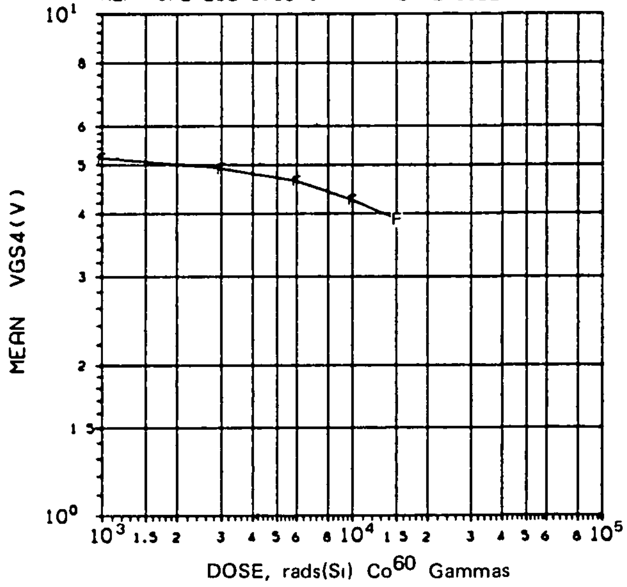


(5) VGS3 (VDS= 5V, IDD=500MA) IN VOLT VS DOSE

TABLE OF NORMAL STANDARD DEVIATIONS				
CURVE	DOSE, kilorads(Si)			
	75	150	300	600
E	1868	1628	.2715	2845

INITIAL MEAN VALUE VGS3(V) = $4.03 \times 10^{+0}$

DEVICE TYPE. IRF150 HEXFET
MFG. INR 3 DEVICES TEST DATE 12-17-82
REF JPL LOG 0953-1 DATE CODE 8213

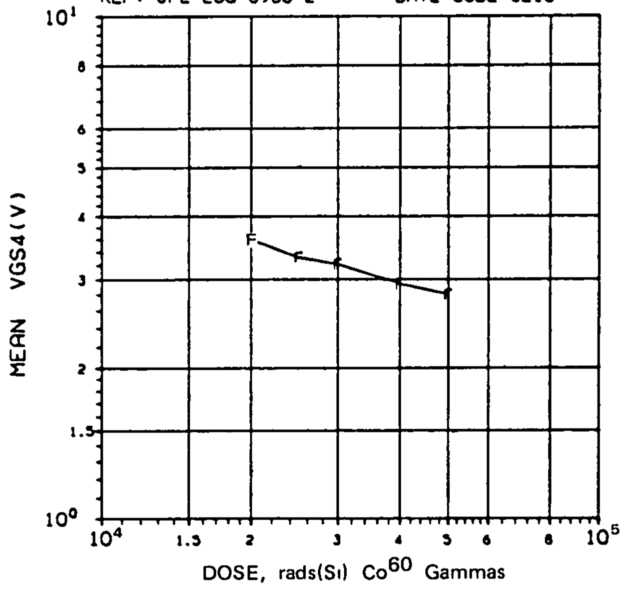


(6) VGS4 (VDS= 5V,IDD=2.0A) IN VOLT VS DOSE

TABLE OF NORMAL STANDARD DEVIATIONS					
CURVE	DOSE, kilorads(Si)				
	1	3	6	10	15
F	3459	3439	3557	3164	2969

INITIAL MEAN VALUE VGS4(V) = $5.11\times10^{+0}$

DEVICE TYPE: IRF150 HEXFET
MFG: INR 3 DEVICES TEST DATE 12-17-82
REF: JPL LOG 0953-2 DATE CODE 8213

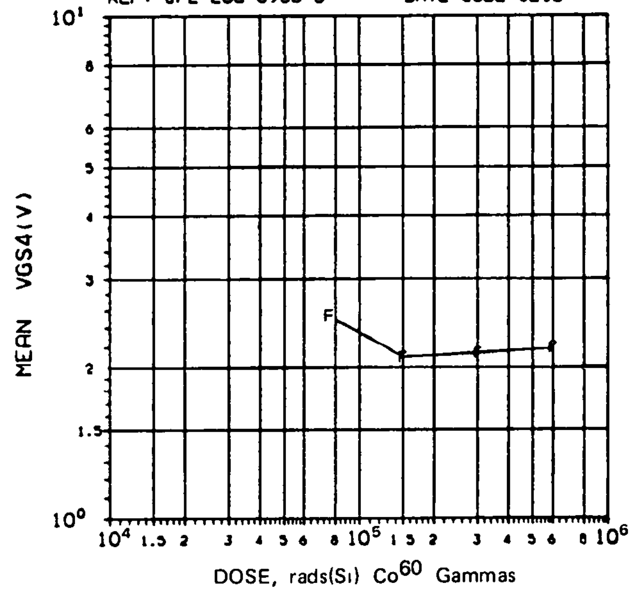


(6) VGS4 (VDS= 5V,IDD=2.0A) IN VOLT VS DOSE

TABLE OF NORMAL STANDARD DEVIATIONS					
CURVE	DOSE, kilorads(Si)				
	20	25	30	40	50
F	3293	2183	2779	2665	.2862

INITIAL MEAN VALUE VGS4(V) = $5.11\times10^{+0}$

DEVICE TYPE: IRF150 HEXFET
MFG: INR 3 DEVICES TEST DATE 12-17-82
REF: JPL LOG 0953-3 DATE CODE 8213

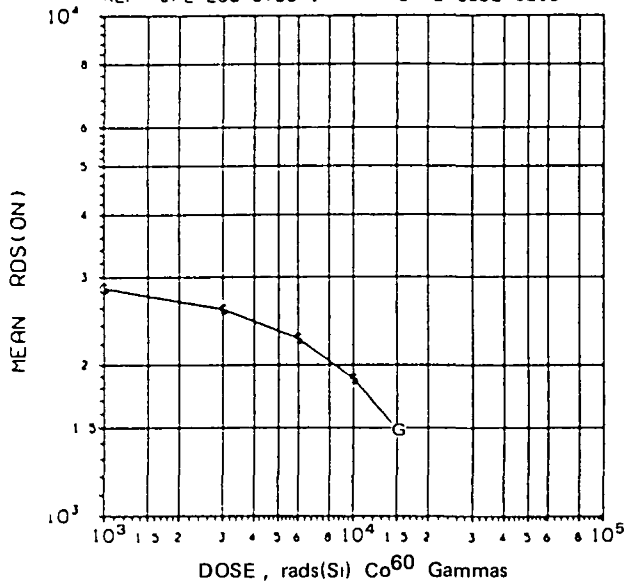


(6) VGS4 (VDS= 5V,IDD=2.0A) IN VOLT VS DOSE

TABLE OF NORMAL STANDARD DEVIATIONS				
CURVE	DOSE, kilorads(Si)			
	75	150	300	600
F	2689	.2411	3500	.4102

INITIAL MEAN VALUE VGS4(V) = $5.11X10^{+0}$

DEVICE TYPE IRF150 HEXFET
MFG INR 3 DEVICES TEST DATE 12-17-82
REF JPL LOG 0953-1 DATE CODE 8213

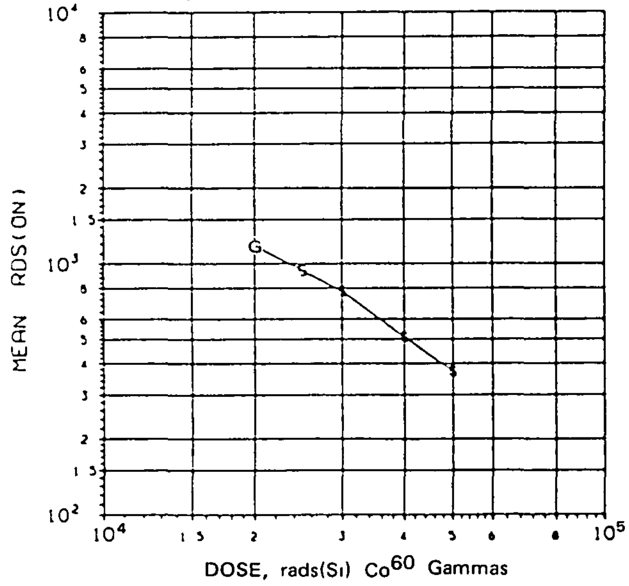


(7) RDSON(VGS=15V, IDD=1MA) IN OHM VS DOSE

TABLE OF NORMAL STANDARD DEVIATIONS					
CURVE	DOSE, kilorads(Si)				
	1	3	6	10	15
G	223 7	205 5	197 3	180 1	158.9

INITIAL MEAN VALUE RDS(ON) = $2.98 \times 10^{+3}$

DEVICE TYPE IRF150 HEXFET
MFG INR 3 DEVICES TEST DATE 12-17-82
REF JPL LOG 0953-2 DATE CODE 8213

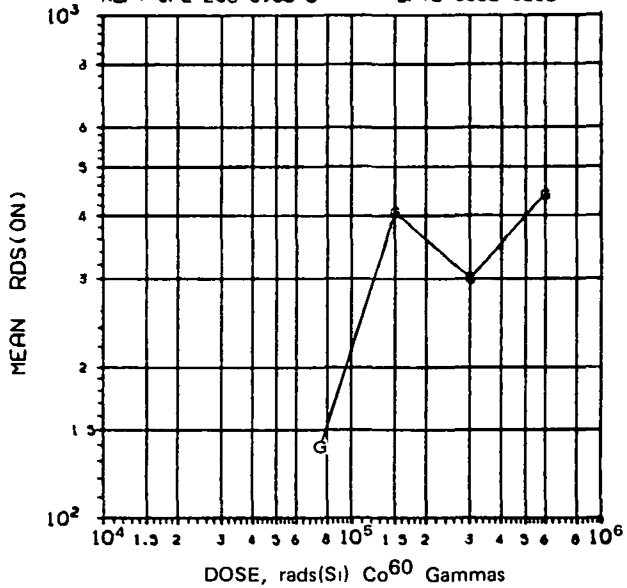


(7) RDSON(VGS=15V, IDD=1MA) IN OHM VS DOSE

TABLE OF NORMAL STANDARD DEVIATIONS					
CURVE	DOSE, kilorads(Si)				
	20	25	30	40	50
G	138 6	138 9	111 2	88 10	71.45

INITIAL MEAN VALUE RDS(ON) = $2\ 98 \times 10^{+3}$

DEVICE TYPE: IRF150 HEXFET
MFG: INR 3 DEVICES TEST DATE 12-17-82
REF: JPL LOG 0953-3 DATE CODE 8213

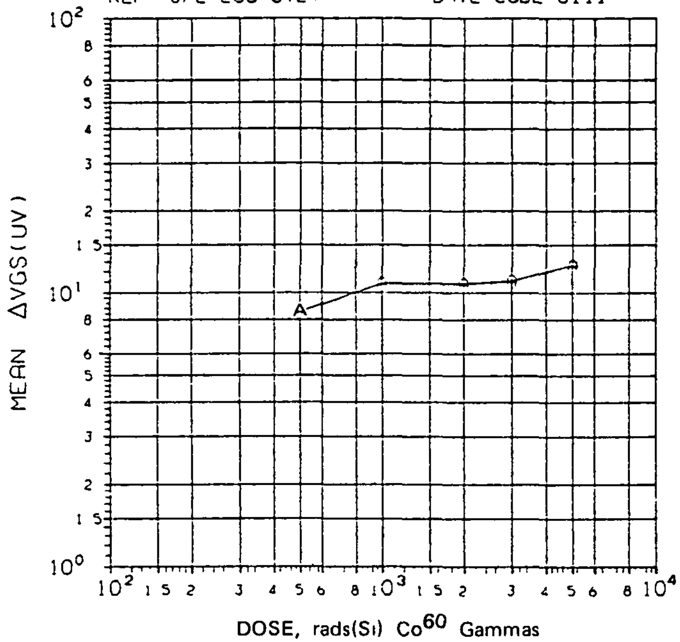


(7) RDSON(VGS=15V,IDD=1MA) IN OHM VS DOSE

TABLE OF NORMAL STANDARD DEVIATIONS				
CURVE	DOSE, kilorads(Si)			
	75	150	300	600
G	65.11	58.59	194.2	82.66

INITIAL MEAN VALUE RDS(ON) = $2.98 \times 10^{+3}$

DEVICE TYPE J230 N-JFET
MFG SIL 5 DEVICES TEST DATE 4-27-81
REF JPL LOG 0727 DATE CODE 8111

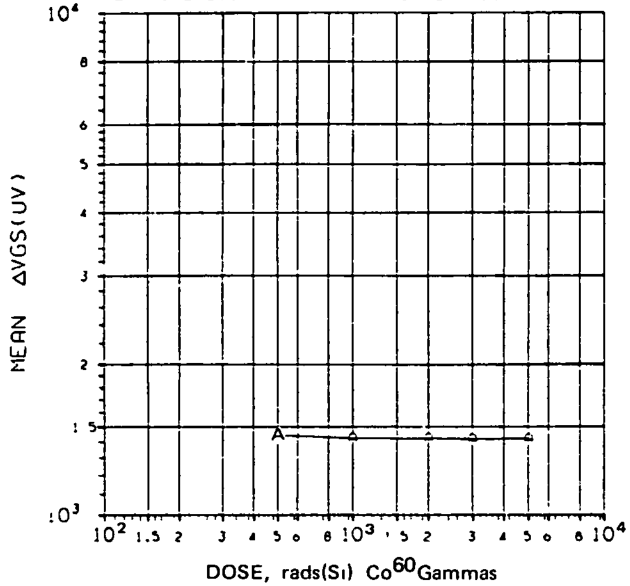


(1) ΔVGS(UV), VGS1-VGS2 VS DOSE

TABLE OF NORMAL STANDARD DEVIATIONS					
CURVE	DOSE, kilorads(Si)				
	.5	1	2	3	5
A	1 293	1 867	1 512	1 346	1 108

INITIAL MEAN VALUE = 7 68X10^{-0}

DEVICE TYPE J230 N-FET
MFG SIL 5 DEVICES TEST DATE 5-6-81
REF · JPL LCG 0731-1 DATE CODE 8035

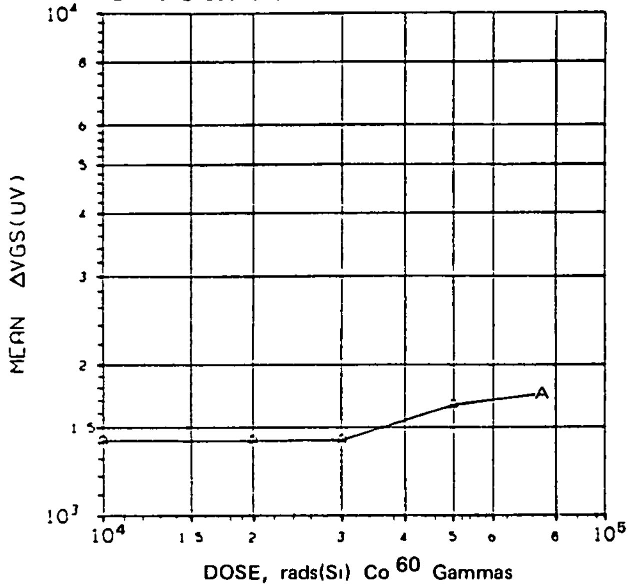


(1)ΔVGS(UV) VGS1-VGS2 VS DOSE

TABLE OF NORMAL STANDARD DEVIATIONS					
CURVE	DOSE, kilorads(Si)				
	1	1	2	3	5
A	1686	1659	1650	1641	1640

INITIAL MEAN VALUE VGS(UV) = 1 44X10+3

DEVICE TYPE J230 N-FET
MFG. SIL 5 DEVICES TEST DATE 5-6-81
REF JPL LCG 0731-2 DATE CODE 8035



(1)ΔVGS(UV) VGS1-VGS2 VS DOSE

TABLE OF NORMAL STANDARD DEVIATIONS					
CURVE	DOSE, kilorads(Si)				
	10	20	30	50	75
A	1625	6 8	1618.	2010	2122

INITIAL MEAN VALUE VGS(UV) = 1 44X10+3

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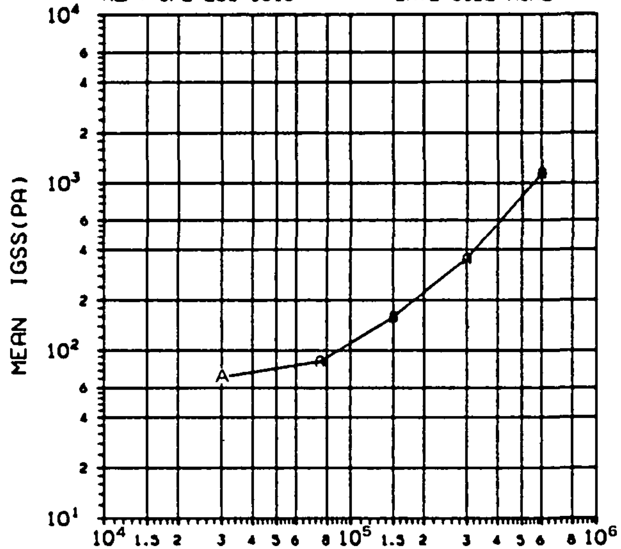
DEVICE TYPE: U401 DUAL N CHAN JFET
MFG: SIL 8 DEVICES TEST DATE 6-1-82
REF: JPL LOG 0816 DATE CODE NONE



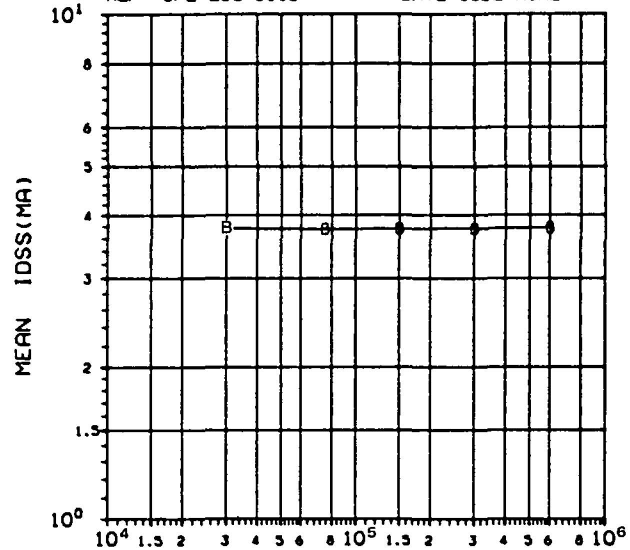
DOSE, rads(Si) 2.5 MeV electrons

(1)IGSS (VDS=0V,VGS=-10V) IN PA: VS DOSE

TABLE OF NORMAL STANDARD DEVIATIONS					
CURVE	DOSE, kilorads(Si)				
	30	75	150	300	600
A	62.48	65.22	85.00	128.6	304.8

INITIAL MEAN VALUE IGSS(PA) = $8.78X10^{+1}$

DEVICE TYPE: U401 DUAL N CHAN JFET
MFG: SIL 8 DEVICES TEST DATE 6-1-82
REF: JPL LOG 0816 DATE CODE NONE



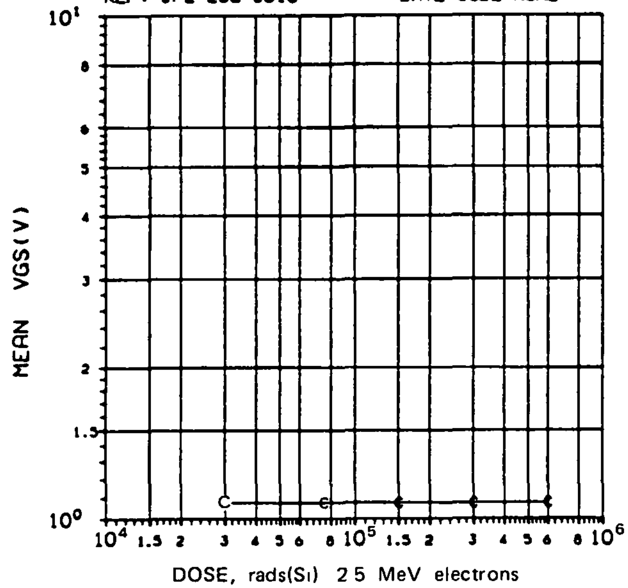
DOSE, rads(Si) 2.5 MeV electrons

(2)IDSS (VDS=10V,VGS=0V) IN MA: VS DOSE

TABLE OF NORMAL STANDARD DEVIATIONS					
CURVE	DOSE, kilorads(Si)				
	30	75	150	300	600
B	.2980	.2966	.3065	.3009	.3250

INITIAL MEAN VALUE IDSS(MA) = $3.80X10^{+0}$

DEVICE TYPE: U401 DUAL N CHAN JFET
MFG: SIL 8 DEVICES TEST DATE 6-1-82
REF: JPL LOG 0816 DATE CODE NONE

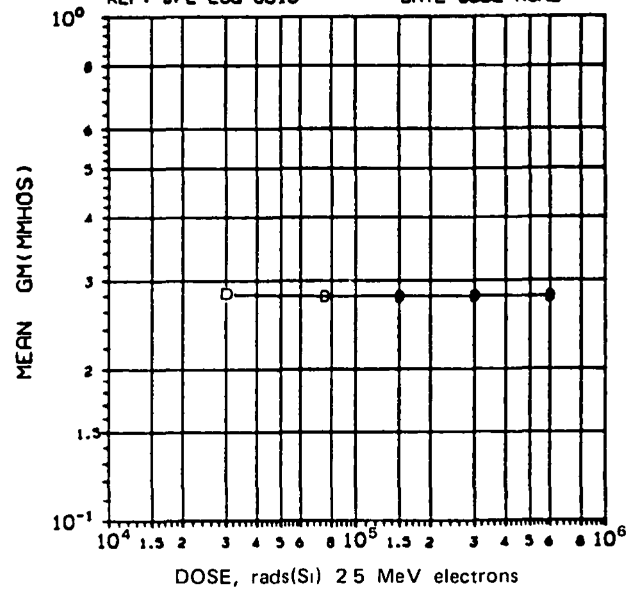


(3)VGS (VDS=10V, ID=300UA) IN VOLTS VS DOSE

TABLE OF NORMAL STANDARD DEVIATIONS					
CURVE	DOSE, kilorads(Si)				
	30	75	150	300	600
C	.0591	.0600	.0604	0597	.0604

INITIAL MEAN VALUE VGS(V) = $1.08 \times 10^{+0}$

DEVICE TYPE: U401 DUAL N CHAN JFET
MFG: SIL 8 DEVICES TEST DATE 6-1-82
REF: JPL LOG 0816 DATE CODE NONE

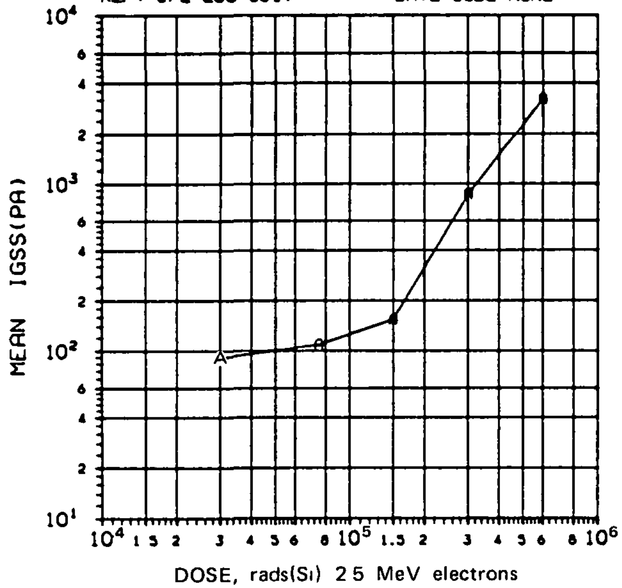


(4)GM (VDS=10V, ID=300UA) IN MMHOS VS DOSE

TABLE OF NORMAL STANDARD DEVIATIONS					
CURVE	DOSE, kilorads(Si)				
	30	75	150	300	600
D	0182	0156	.0152	.0152	.0153

INITIAL MEAN VALUE GM(MMHOS) = 2.79×10^{-1}

DEVICE TYPE: U401 DUAL N CHAN JFET
MFG: SIL 8 DEVICES TEST DATE 6-2-82
REF: JPL LOG 0817 DATE CODE NONE

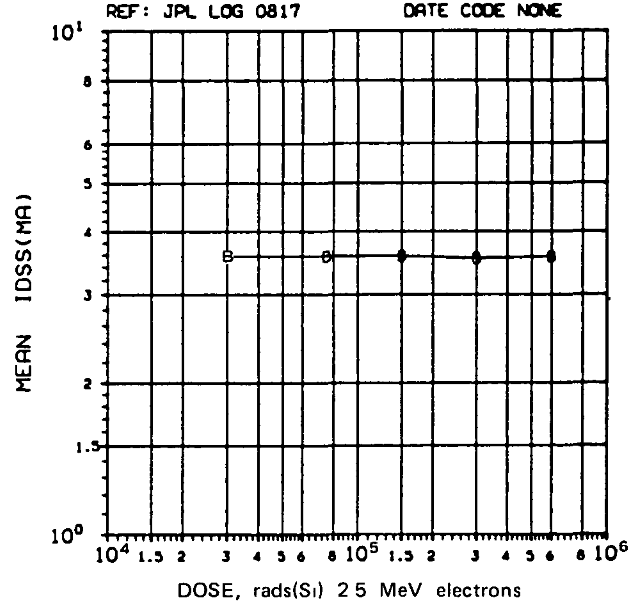


(1)IGSS (VDS=0V,VGS=-10V) IN PA: VS DOSE

TABLE OF NORMAL STANDARD DEVIATIONS					
CURVE	DOSE, kilorads(Si)				
	30	75	150	300	600
A	74.15	90.25	93.35	1915.	5779

INITIAL MEAN VALUE IGSS(PA) = $9.81X10^{+1}$

DEVICE TYPE: U401 DUAL N CHAN JFET
MFG: SIL 8 DEVICES TEST DATE 6-2-82
REF: JPL LOG 0817 DATE CODE NONE



(2)IDSS (VDS=10V,VGS=0V) IN MA: VS DOSE

TABLE OF NORMAL STANDARD DEVIATIONS					
CURVE	DOSE, kilorads(Si)				
	30	75	150	300	600
B	1.261	1.264	1.267	1.244	1.259

INITIAL MEAN VALUE IDSS(MA) = $3.52X10^{+0}$

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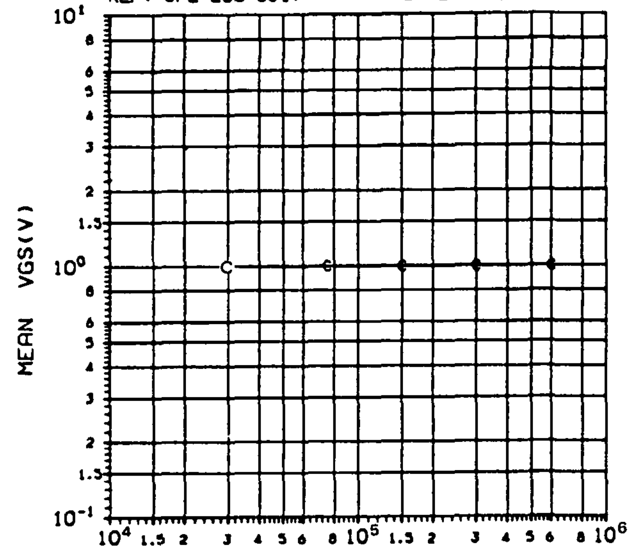
DEVICE TYPE: U401 DUAL N CHAN JFET
MFG: SIL   8 DEVICES   TEST DATE 6-2-82
REF: JPL LOG 0817   DATE CODE NONE



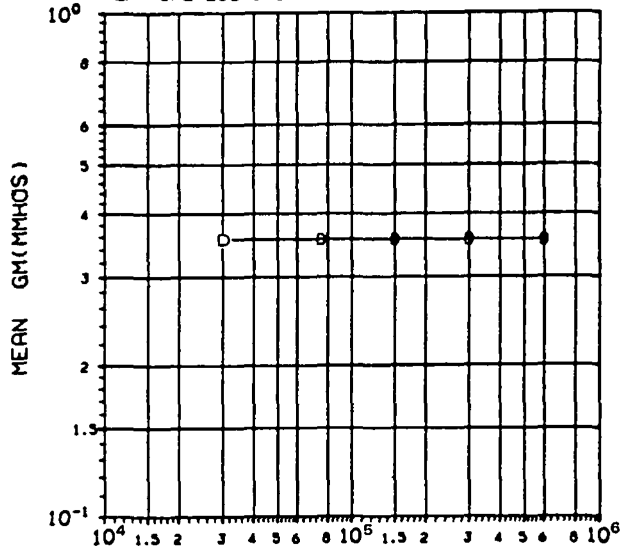
DOSE, rads(Si) 2.5 MeV electrons

(3)VGS (VDS=10V, ID=300UA) IN VOLTS VS DOSE

TABLE OF NORMAL STANDARD DEVIATIONS					
CURVE	DOSE, kilorads(Si)				
	30	75	150	300	600
C	.3380	.3380	.3380	.3381	.3379

INITIAL MEAN VALUE VGS(V) $= 9.99\times10^{-1}$

DEVICE TYPE: U401 DUAL N CHAN JFET
MFG: SIL   8 DEVICES   TEST DATE 6-2-82
REF: JPL LOG 0817   DATE CODE NONE



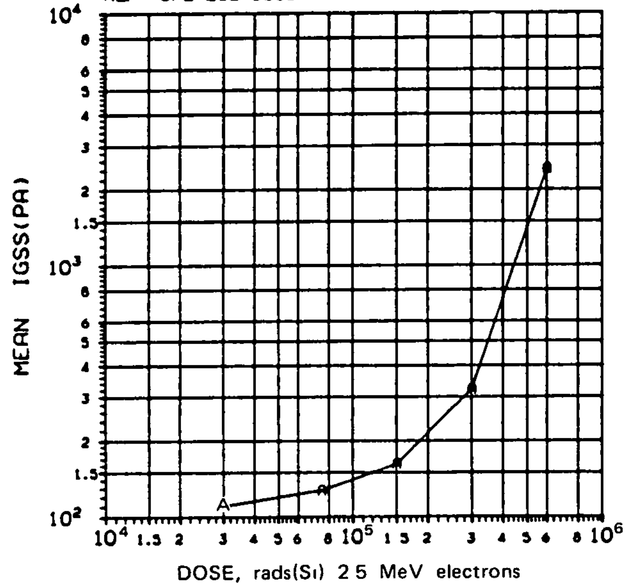
DOSE, rads(Si) 2.5 MeV electrons

(4)GM (VDS=10V, ID=300UA) IN MMHOS VS DOSE

TABLE OF NORMAL STANDARD DEVIATIONS					
CURVE	DOSE, kilorads(Si)				
	30	75	150	300	600
D	.1880	.1880	.1880	.1881	.1877

INITIAL MEAN VALUE GM(MMHOS) $= 3.55\times10^{-1}$

DEVICE TYPE: U401 DUAL N CHAN JFET
MFG: SIL 8 DEVICES TEST DATE 6-2-82
REF: JPL LOG 0818 DATE CODE NONE

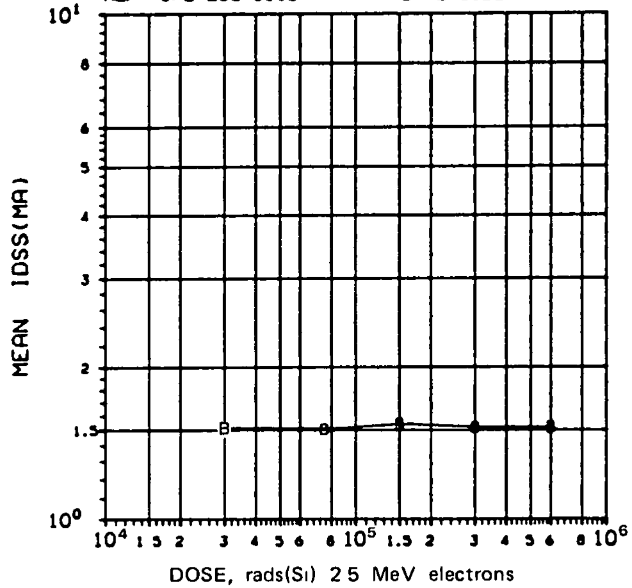


(1)IGSS (VDS=0V,VGS=-10V) IN PA: VS DOSE

TABLE OF NORMAL STANDARD DEVIATIONS					
CURVE	DOSE, kilorads(Si)				
	30	75	150	300	600
A	86.27	98 61	70.24	73.23	4279.

INITIAL MEAN VALUE IGSS(PA) = $1.52 \times 10^{+2}$

DEVICE TYPE: U401 DUAL N CHAN JFET
MFG: SIL 8 DEVICES TEST DATE 6-2-82
REF: JPL LOG 0818 DATE CODE NONE

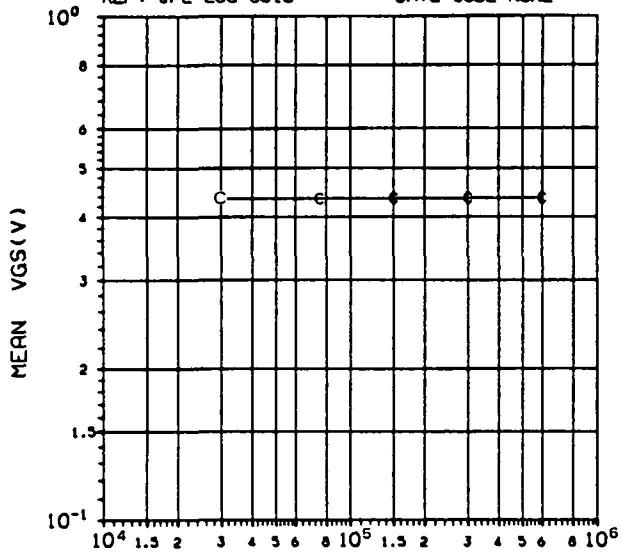


(2)IDSS (VDS=10V,VGS=0V) IN MA: VS DOSE

TABLE OF NORMAL STANDARD DEVIATIONS					
CURVE	DOSE, kilorads(Si)				
	30	75	150	300	600
B	.6099	6237	.6471	.6106	.6111

INITIAL MEAN VALUE IDSS(MA) = $1.52 \times 10^{+0}$

DEVICE TYPE: U401 DUAL N CHAN JFET
MFG: SIL 8 DEVICES TEST DATE 6-2-82
REF: JPL LOG 0818 DATE CODE NONE

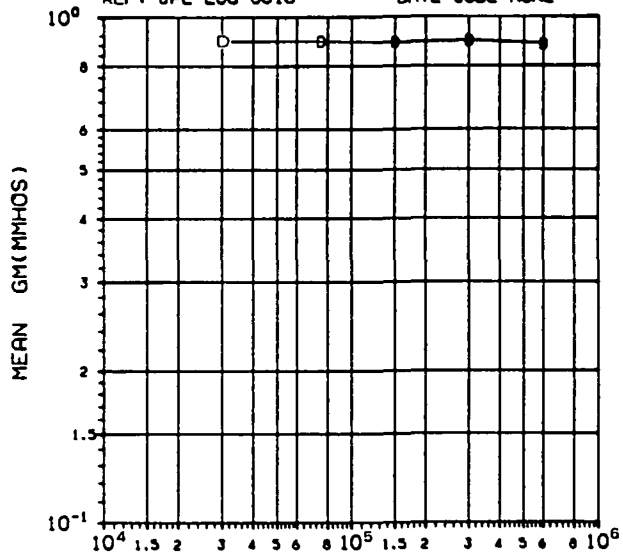


(3)VGS (VDS=10V, ID=300UA) IN VOLTS VS DOSE

TABLE OF NORMAL STANDARD DEVIATIONS					
CURVE	DOSE, kilorads(Si)				
	30	75	150	300	600
C	.1923	1923	1919	.1922	.1923

INITIAL MEAN VALUE VGS(V) = 4.35×10^{-1}

DEVICE TYPE: U401 DUAL N CHAN JFET
MFG: SIL 8 DEVICES TEST DATE 6-2-82
REF: JPL LOG 0818 DATE CODE NONE

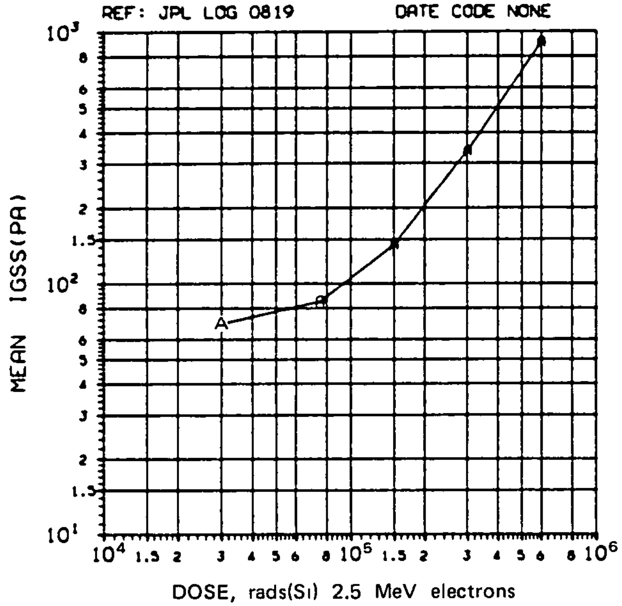


(4)GM (VDS=10V, ID=300UA) IN MMHOS VS DOSE

TABLE OF NORMAL STANDARD DEVIATIONS					
CURVE	DOSE, kilorads(Si)				
	30	75	150	300	600
D	5686	.5687	5641	5589	.5655

INITIAL MEAN VALUE GM(MMHOS) = 8.96×10^{-1}

DEVICE TYPE: U401 DUAL N CHAN JFET
MFG: SIL 8 DEVICES TEST DATE 6-10-82
REF: JPL LOG 0819 DATE CODE NONE

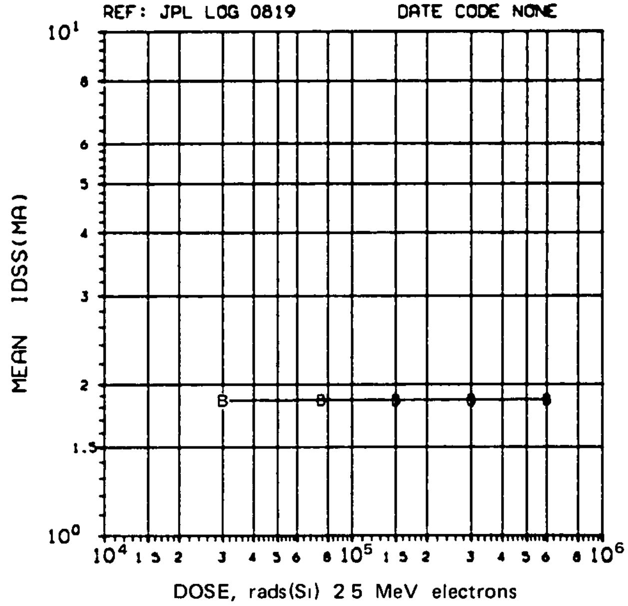


(1) IGSS (VDS=0V, VGS=-10V) IN PA: VS DOSE

TABLE OF NORMAL STANDARD DEVIATIONS					
CURVE	DOSE, kilorads(Si)				
	30	75	150	300	600
A	65.50	63 34	66.30	74 44	135.7

INITIAL MEAN VALUE IGSS(PA) = $1.06 \times 10^{+2}$

DEVICE TYPE: U401 DUAL N CHAN JFET
MFG: SIL 8 DEVICES TEST DATE 6-10-82
REF: JPL LOG 0819 DATE CODE NONE



(2) IDSS (VDS=10V, VGS=0V) IN MA: VS DOSE

TABLE OF NORMAL STANDARD DEVIATIONS					
CURVE	DOSE, kilorads(Si)				
	30	75	150	300	600
B	.6037	6080	.6082	.6080	.6094

INITIAL MEAN VALUE IDSS(MA) = $1.86 \times 10^{+0}$

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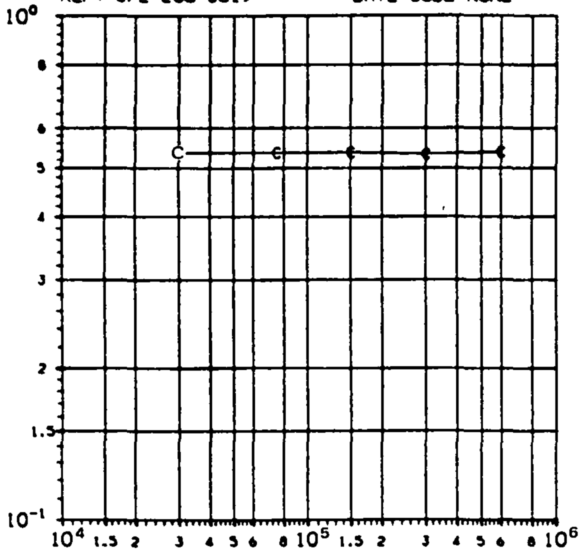
OF POOR QUALITY

DEVICE TYPE: U401 DUAL N CHAN JFET
MFG: SIL 8 DEVICES TEST DATE 6-10-82
REF: JPL LOG 0819 DATE CODE NONE



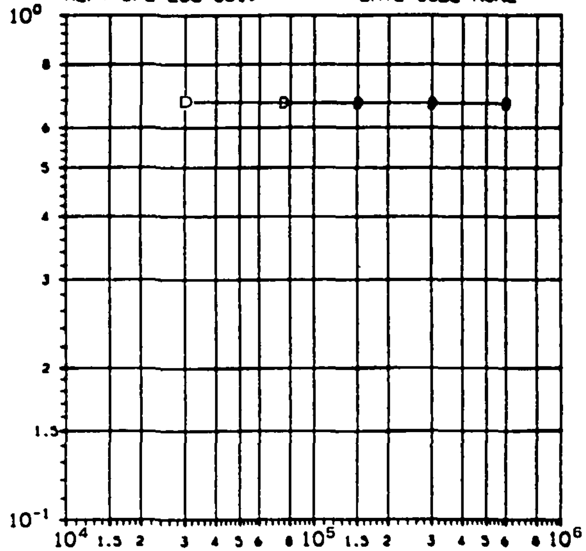
DOSE, rads(Si) 2.5 MeV electrons

(3)VGS (VDS=10V, ID=300UA) IN VOLTS VS DOSE

TABLE OF NORMAL STANDARD DEVIATIONS					
CURVE	DOSE, kilorads(Si)				
	30	75	150	300	600
C	.1857	1857	1858	.1827	1860

INITIAL MEAN VALUE VGS(V) = 5.36×10^{-1}

DEVICE TYPE: U401 DUAL N CHAN JFET
MFG: SIL 8 DEVICES TEST DATE 6-10-82
REF: JPL LOG 0819 DATE CODE NONE



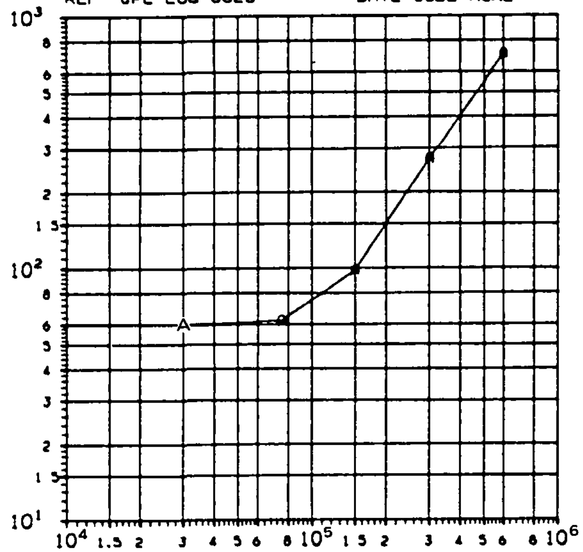
DOSE, rads(Si) 2.5 MeV electrons

(4)GM (VDS=10V, ID=300UA) IN MMHOS VS DOSE

TABLE OF NORMAL STANDARD DEVIATIONS					
CURVE	DOSE, kilorads(Si)				
	30	75	150	300	600
D	3742	3695	.3697	.3701	.3679

INITIAL MEAN VALUE GM(MMHOS) = 6.71×10^{-1}

DEVICE TYPE: U401 DUAL N CHAN JFET
MFG: SIL 8 DEVICES TEST DATE 6-10-82
REF: JPL LOG 0820 DATE CODE NONE



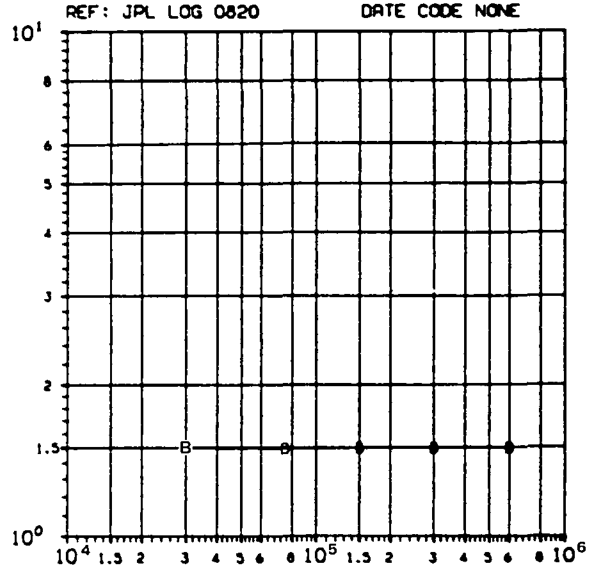
DOSE, rads(Si) 2.5 MeV electrons

(1)IGSS (VDS=0V,VGS=-10V) IN PA: VS DOSE

TABLE OF NORMAL STANDARD DEVIATIONS					
CURVE	DOSE, kilorads(Si)				
	30	75	150	300	600
A	16.21	11 87	9.152	15.95	22.73

INITIAL MEAN VALUE IGSS(PA) = 1 01X10+2

DEVICE TYPE: U401 DUAL N CHAN JFET
MFG: SIL 8 DEVICES TEST DATE 6-10-82
REF: JPL LOG 0820 DATE CODE NONE



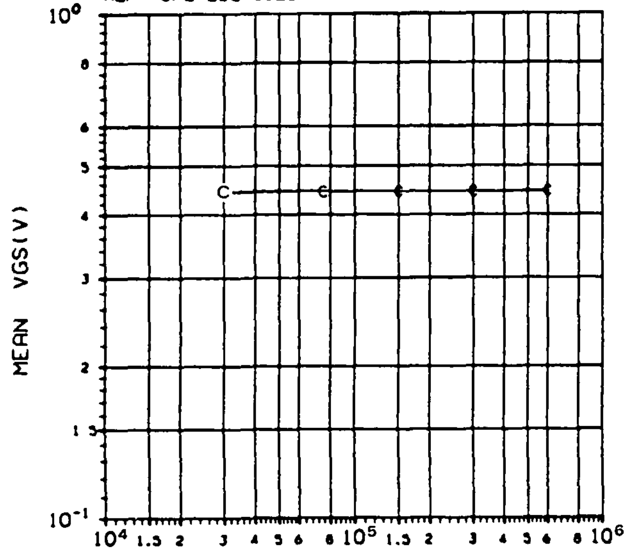
DOSE, rads(Si) 2.5 MeV electrons

(2)IDSS (VDS=10V,VGS=0V) IN MA: VS DOSE

TABLE OF NORMAL STANDARD DEVIATIONS					
CURVE	DOSE, kilorads(Si)				
	30	75	150	300	600
B	0607	0641	0612	.0612	.0602

INITIAL MEAN VALUE IDSS(MA) = 1.49X10+0

DEVICE TYPE: U401 DUAL N CHAN JFET
MFG: SIL 8 DEVICES TEST DATE 6-10-82
REF: JPL LOG 0820 DATE CODE NONE



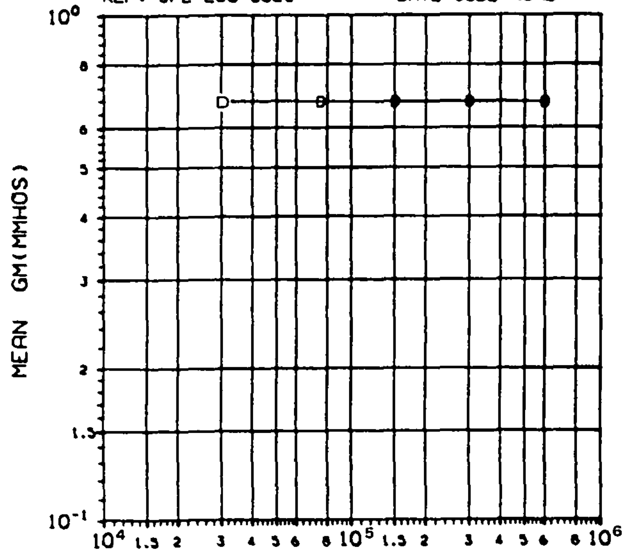
DOSE, rads(Si) 2.5 MeV electrons

(3)VGS (VDS=10V, ID=300UA) IN VOLTS VS DOSE

TABLE OF NORMAL STANDARD DEVIATIONS					
CURVE	DOSE, kilorads(Si)				
	30	75	150	300	600
C	0182	.0184	0184	.0184	0177

INITIAL MEAN VALUE VGS(V) = 4.45×10^{-1}

DEVICE TYPE: U401 DUAL N CHAN JFET
MFG: SIL 8 DEVICES TEST DATE 6-10-82
REF: JPL LOG 0820 DATE CODE NONE



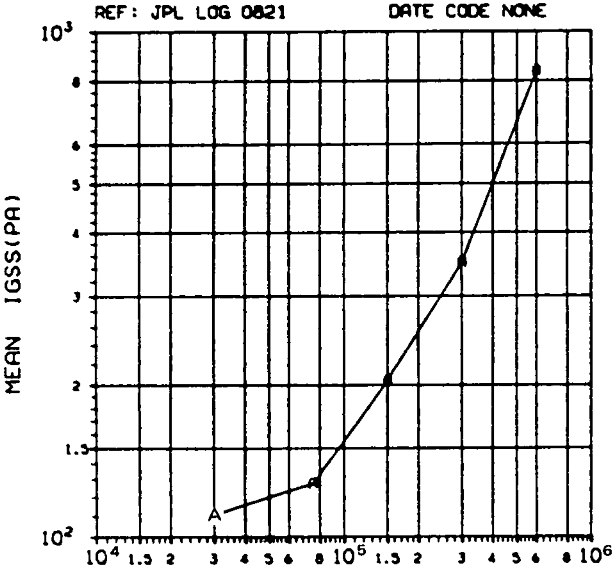
DOSE, rads(Si) 2.5 MeV electrons

(4)GM (VDS=10V, ID=300UA) IN MMHOS VS DOSE

TABLE OF NORMAL STANDARD DEVIATIONS					
CURVE	DOSE, kilorads(Si)				
	30	75	150	300	600
D	0285	.0287	.0287	.0287	0274

INITIAL MEAN VALUE GM(MMHOS) = 6.76×10^{-1}

DEVICE TYPE: U401 DUAL N CHAN JFET
MFG: SIL 8 DEVICES TEST DATE 6-11-82
REF: JPL LOG 0821 DATE CODE NONE



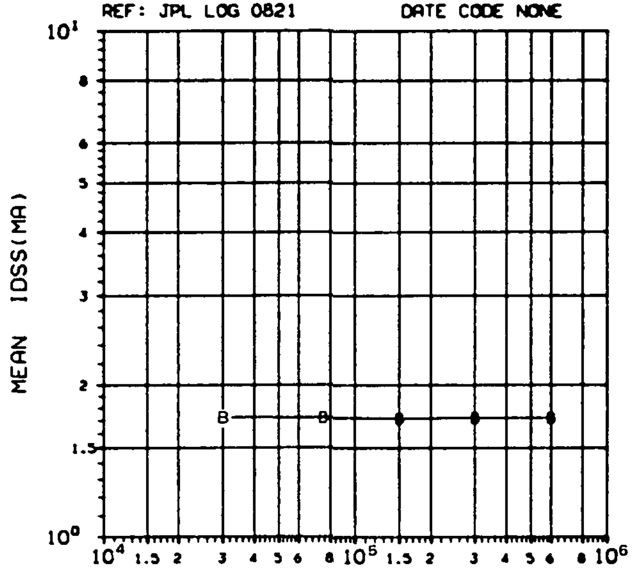
DOSE, rads(Si) 2.5 MeV electrons

(1)IGSS (VDS=0V,VGS=-10V) IN PA: VS DOSE

TABLE OF NORMAL STANDARD DEVIATIONS					
CURVE	DOSE, kilorads(Si)				
	30	75	150	300	600
A	87.23	90 70	97.99	91.37	123.5

INITIAL MEAN VALUE IGSS(PA) = $1.35 \times 10^{+2}$

DEVICE TYPE: U401 DUAL N CHAN JFET
MFG: SIL 8 DEVICES TEST DATE 6-11-82
REF: JPL LOG 0821 DATE CODE NONE



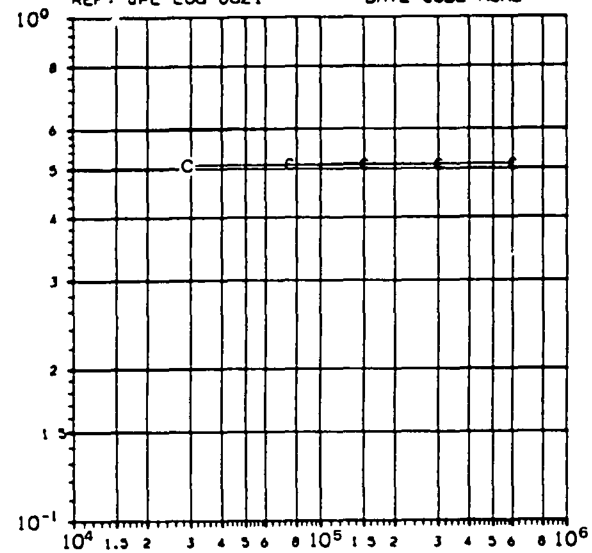
DOSE, rads(Si) 2.5 MeV electrons

(2)IDSS (VDS=10V,VGS=0V) IN MA: VS DOSE

TABLE OF NORMAL STANDARD DEVIATIONS					
CURVE	DOSE, kilorads(Si)				
	30	75	150	300	600
B	1335	.1330	.1298	1318	.1318

INITIAL MEAN VALUE IDSS(MA) = $1.72 \times 10^{+0}$

DEVICE TYPE: U401 DUAL N CHAN JFET
MFG. SIL   8 DEVICES   TEST DATE 6-11-82
REF: JPL LOG 0821   DATE CODE NONE



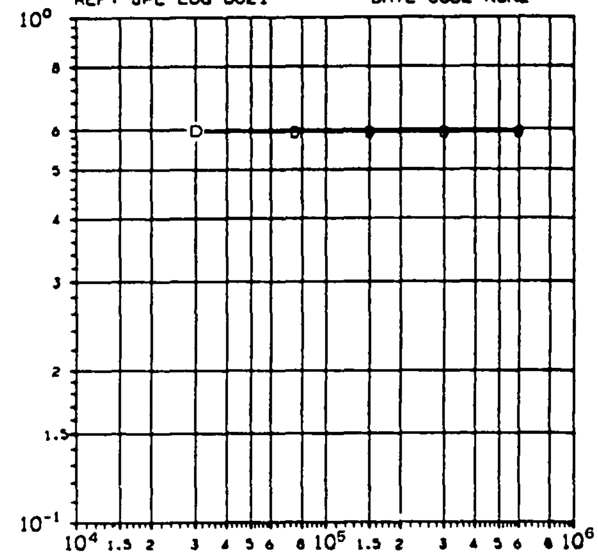
DOSE, rads(Si) 2.5 MeV electrons

(3)VGS (VDS=10V, ID=300UA) IN VOLTS VS DOSE

TABLE OF NORMAL STANDARD DEVIATIONS					
CURVE	DOSE, kilorads(Si)				
	30	75	150	300	600
C	0415	0417	.0417	0414	.0416

INITIAL MEAN VALUE VGS(V) = 5.09×10^{-1}

DEVICE TYPE: U401 DUAL N CHAN JFET
MFG: SIL   8 DEVICES   TEST DATE 6-11-82
REF: JPL LOG 0821   DATE CODE NONE



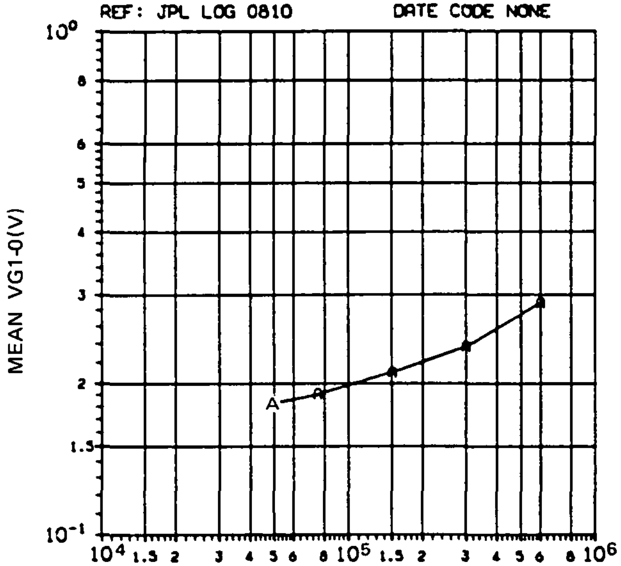
DOSE, rads(Si) 2.5 MeV electrons

(4)GM (VDS=10V, ID=300UA) IN MMHOS VS DOSE

TABLE OF NORMAL STANDARD DEVIATIONS					
CURVE	DOSE, kilorads(Si)				
	30	75	150	300	600
D	0482	0485	0484	.0482	0470

INITIAL MEAN VALUE GM(MMHOS) = 5.93×10^{-1}

DEVICE TYPE: U423 N-CHAN FET
MFG: SIL 4 DEVICES TEST DATE 5-21-82
REF: JPL LOG 0810 DATE CODE NONE



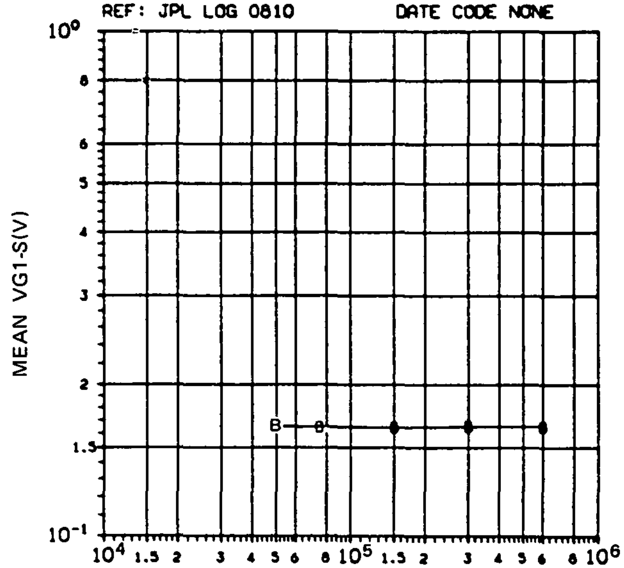
DOSE, rads(Si) 2.5 MeV electrons

(1)VG1(OPEN,VDD=7V,VSS=-7V) VOLTS: VS DOSE

TABLE OF NORMAL STANDARD DEVIATIONS					
CURVE	DOSE, kilorads(Si)				
	50	75	150	300	600
A	.0126	0124	0117	0062	.0065

INITIAL MEAN VALUE EG1-O(V) = 1.79×10^{-1}

DEVICE TYPE: U423 N-CHAN FET
MFG: SIL 4 DEVICES TEST DATE 5-21-82
REF: JPL LOG 0810 DATE CODE NONE



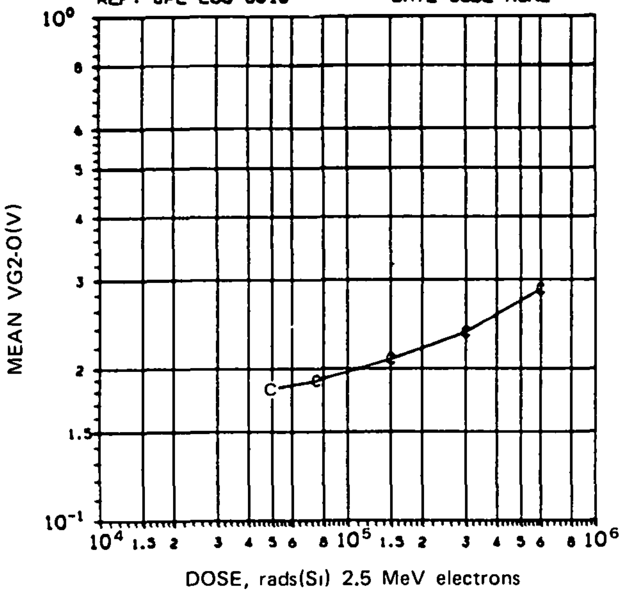
DOSE, rads(Si) 2.5 MeV electrons

(2)VG1(SHORT,VDD=7V,VSS=-7V) VOLTS: VS DOSE

TABLE OF NORMAL STANDARD DEVIATIONS					
CURVE	DOSE, kilorads(Si)				
	50	75	150	300	600
B	.0063	.0071	.0062	.0064	.0065

INITIAL MEAN VALUE EG1-S(V) = 1.69×10^{-1}

DEVICE TYPE: U423 N-CHAN FET
MFG: SIL 4 DEVICES TEST DATE 5-21-82
REF: JPL LOG 0810 DATE CODE NONE

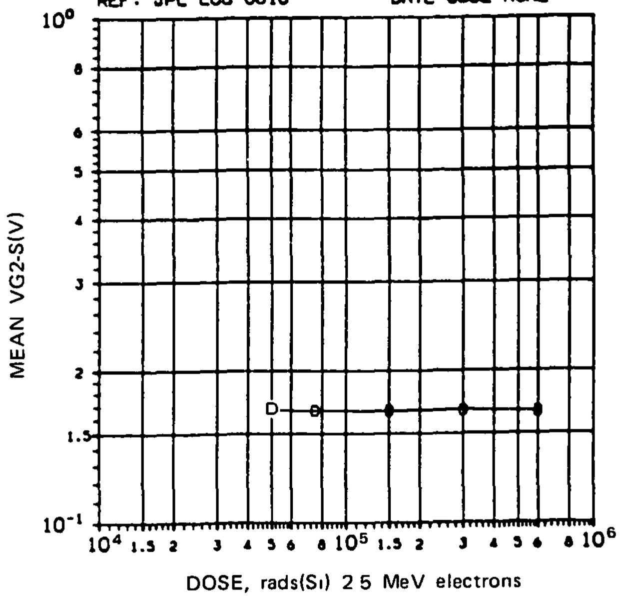


(3)VG2(OPEN,VDD=7V,VSS=-7V) VOLTS: VS DOSE

TABLE OF NORMAL STANDARD DEVIATIONS					
CURVE	DOSE, kilorads(Si)				
	50	75	150	300	600
C	.0077	.0101	.0070	.0086	0170

INITIAL MEAN VALUE EG2-O(V) = 1.82×10^{-1}

DEVICE TYPE: U423 N-CHAN FET
MFG: SIL 4 DEVICES TEST DATE 5-21-82
REF: JPL LOG 0810 DATE CODE NONE

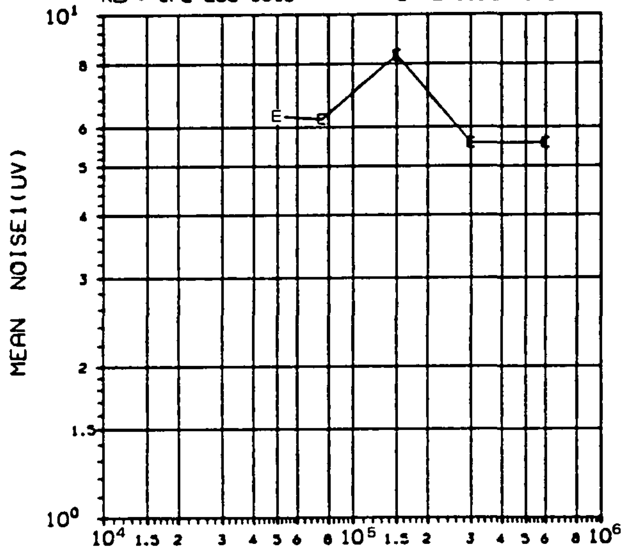


(4)VG2(SHORT,VDD=7V,VSS=-7V) VOLTS: VS DOSE

TABLE OF NORMAL STANDARD DEVIATIONS					
CURVE	DOSE, kilorads(Si)				
	50	75	150	300	600
D	.0083	0085	.0077	.0085	.0077

INITIAL MEAN VALUE EG2-S(V) = 1.70×10^{-1}

DEVICE TYPE: U423 N-CHAN FET
MFG: SIL 4 DEVICES TEST DATE 5-21-82
REF: JPL LOG 0810 DATE CODE NONE



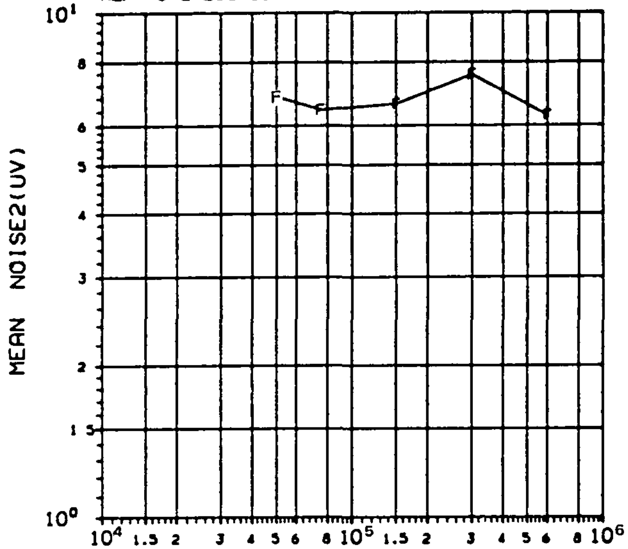
DOSE, rads(Si) 2.5 MeV electrons

(5)NOISE-1(VDS=5V,IDS=30UA) IN UV: VS DOSE

TABLE OF NORMAL STANDARD DEVIATIONS					
CURVE	DOSE, kilorads(Si)				
	50	75	150	300	600
E	.4082	.4992	1.544	.6702	6292

INITIAL MEAN VALUE NOISE1(UV) = $4.90X10^{-0}$

DEVICE TYPE: U423 N-CHAN FET
MFG: SIL 4 DEVICES TEST DATE 5-21-82
REF: JPL LOG 0810 DATE CODE NONE



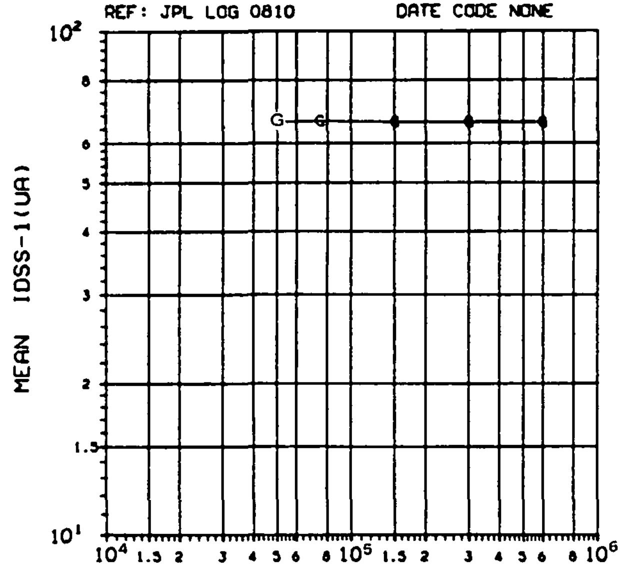
DOSE, rads(Si) 2.5 MeV electrons

(6)NOISE-2(VDS=5V,IDS=30UA) IN UV: VS DOSE

TABLE OF NORMAL STANDARD DEVIATIONS					
CURVE	DOSE, kilorads(Si)				
	50	75	150	300	600
F	1.139	.4933	1.477	2.958	.4787

INITIAL MEAN VALUE NOISE2(UV) = $5.57X10^{-0}$

DEVICE TYPE: U423 N-CHAN FET
MFG: SIL 4 DEVICES TEST DATE 5-21-82
REF: JPL LOG 0810 DATE CODE NONE

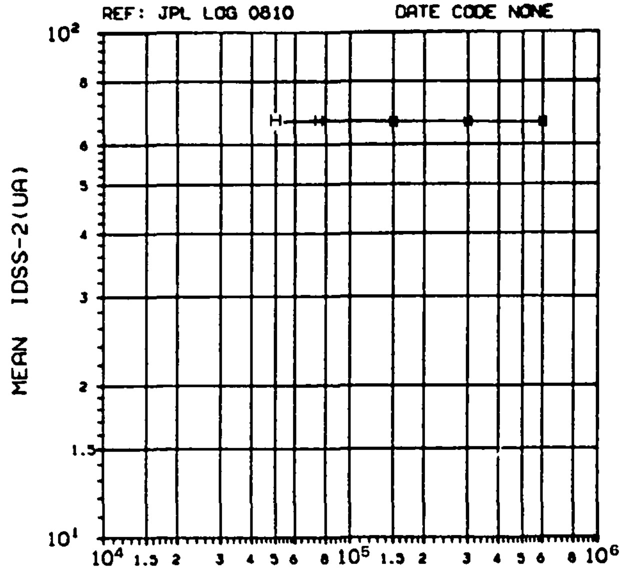


(7)IDSS-1(VDS=10V,VGS=0) IN UA: VS DOSE

TABLE OF NORMAL STANDARD DEVIATIONS					
CURVE	DOSE, kilorads(Si)				
	50	75	150	300	600
G	2.808	2.873	2.758	2.880	3.008

INITIAL MEAN VALUE IDSS-1(UA) = 6.65X10^{+1}

DEVICE TYPE: U423 N-CHAN FET
MFG: SIL 4 DEVICES TEST DATE 5-21-82
REF: JPL LOG 0810 DATE CODE NONE



(8)IDSS-2(VDS=10V,VGS=0) IN UA: VS DOSE

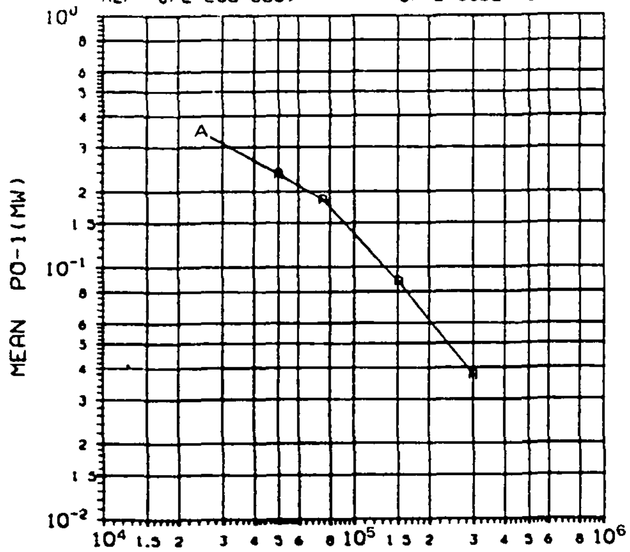
TABLE OF NORMAL STANDARD DEVIATIONS					
CURVE	DOSE, kilorads(Si)				
	50	75	150	300	600
H	2 873	2.783	2.851	2.865	2.943

INITIAL MEAN VALUE IDSS-2(UA) = 6.71X10^{+1}

E. OPTICAL DEVICES

Each optical device uses a Gallium Arsenide (GaAs) infrared-emitting diode (IR-LED). The emission efficiency of GaAs LEDs is greatly reduced by irradiation due to bulk damage.

DEVICE TYPE TIL24 INFRARED DIODE
MFG TIX 4 DEVICES TEST DATE 4-21-82
REF JPL LOG 0809 DATE CODE NONE

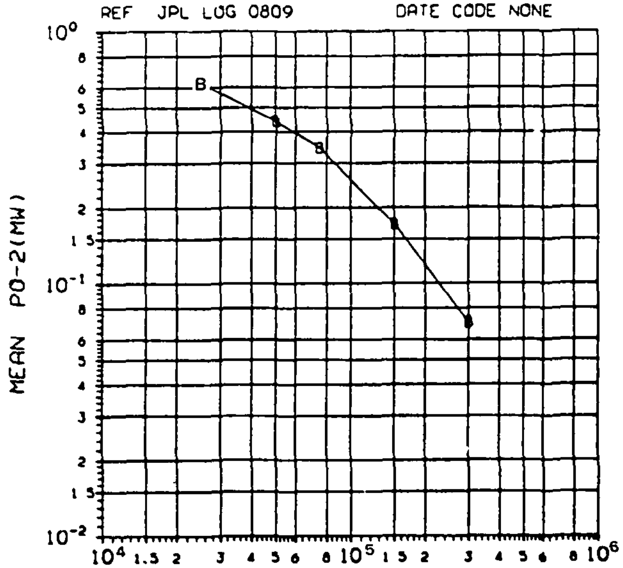


(1)POWER OUTPUT IN MW(IF=30MA): VS DOSE

TABLE OF NORMAL STANDARD DEVIATIONS					
CURVE	DOSE, kilorads(Si)				
	25	50	75	150	300
A	.0806	.0557	0500	0250	0150

INITIAL MEAN VALUE PO-1(MW) = 5.32×10^{-1}

DEVICE TYPE TIL24 INFRARED DIODE
MFG TIX 4 DEVICES TEST DATE 4-21-82
REF JPL LOG 0809 DATE CODE NONE

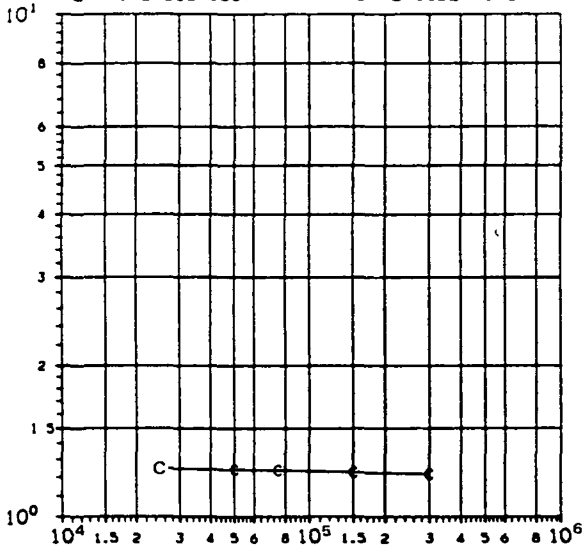


(2)POWER OUTPUT IN MW(IF=50MA): VS DOSE

TABLE OF NORMAL STANDARD DEVIATIONS					
CURVE	DOSE, kilorads(Si)				
	25	50	75	150	300
B	1320	1068	0889	.0499	0216

INITIAL MEAN VALUE PO-2(MW) = $9\ 20\times10^{-1}$

DEVICE TYPE TIL24 INFRARED DIODE
MFG TIX 4 DEVICES TEST DATE 4-21-82
REF JPL LOG 0809 DATE CODE NONE



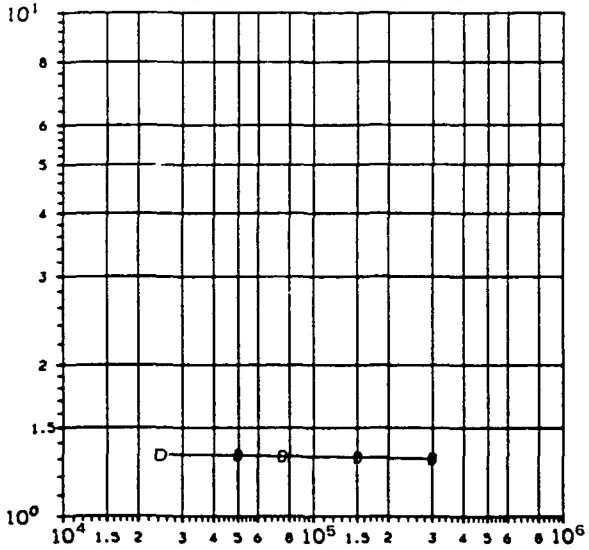
DOSE, rads(Si) 2.5 MeV electrons

(3)FORWARD VOLTAGE IN VOLTS(IF=50MA VS DOSE

TABLE OF NORMAL STANDARD DEVIATIONS					
CURVE	DOSE, kilorads(Si)				
	25	50	75	150	300
C	0175	.0187	.0186	.0194	.0195

INITIAL MEAN VALUE VF-1(V) = 1.25X10⁻⁰

DEVICE TYPE TIL24 INFRARED DIODE
MFG TIX 4 DEVICES TEST DATE 4-21-82
REF JPL LOG 0809 DATE CODE NONE



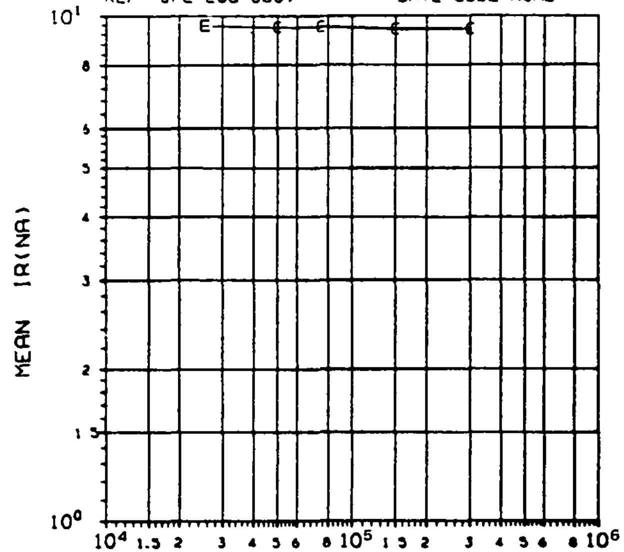
DOSE, rads(Si) 2.5 MeV electrons

(4)FORWARD VOLTAGE IN VOLTS(IF=50MA VS DOSE

TABLE OF NORMAL STANDARD DEVIATIONS					
CURVE	DOSE, kilorads(Si)				
	25	50	75	150	300
D	0281	0279	0292	.0293	0297

INITIAL MEAN VALUE VF-2(V) = 1.33X10⁻⁰

DEVICE TYPE TIL24 INFRARED DIODE
MFG TIX 4 DEVICES TEST DATE 4 21-82
REF JPL LOG 0809 DATE CODE NONE

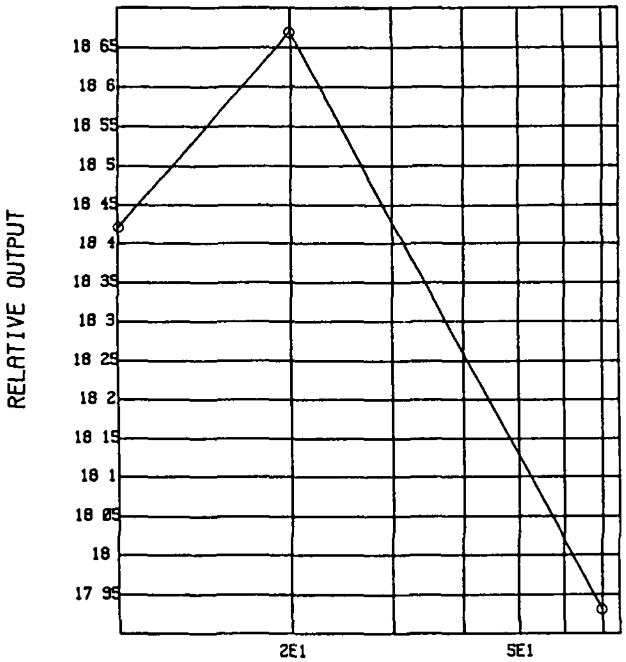


(5)REVERSE CURRENT IN NA(VR=-1.0V): VS DOSE

TABLE OF NORMAL STANDARD DEVIATIONS					
CURVE	DOSE, kilorads(Si)				
	25	50	75	150	300
E	17 62	17.67	17 65	17.72	17.72

INITIAL MEAN VALUE IR(NA) = 9 60X10^-9

DEVICE TYPE TIL-24 IR-LED
MFG TIX 10DEVICE(S) TEST DATE 12/15/83
REF JPL LOG# 1023 DATE CODE

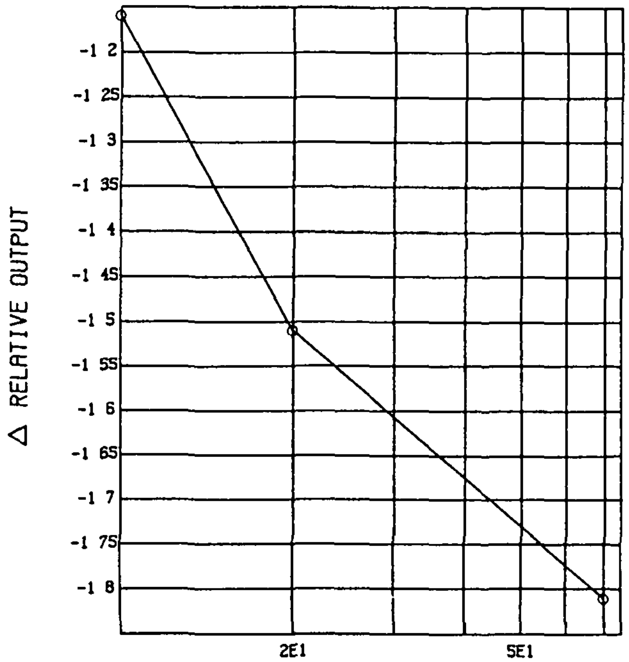


(1) RELATIVE OUTPUT vs DOSE

TABLE OF NORMAL STANDARD DEVIATIONS		
DOSE, rads(Si)		
1E1	2E1	7E1
2 4E0	2 6E0	3 4E0

INITIAL MEAN VALUE (RELATIVE OUTPUT) = 2E1

DEVICE TYPE TIL-24 IR-LED
MFG TIX 10DEVICE(S) TEST DATE 12-15-83
REF JPL LOG# 1023 DATE CODE NONE



(2) ΔRELATIVE OUTPUT vs DOSE

TABLE OF NORMAL STANDARD DEVIATIONS		
DOSE, rads(Si)		
1E1	2E1	7E1
2 3E1	2 3E1	2 4E1

INITIAL MEAN VALUE (RELATIVE OUTPUT) = 2E1

APPENDIX A

VENDOR CODE IDENTIFICATION LIST

VENDOR CODE IDENTIFICATION LIST

INR	International Rectifier Semiconductor, Inc.
MOT	Motorola, Inc., Semiconductor Products Division
NSC	National Semiconductor Corp.
RAY	Raytheon Company
SCN	Semicon, Inc.
SIL	Siliconix Devices, Inc.
SOD	Solitron Devices, Inc.
TIX	Texas Instruments, Inc.
UTR	Unitrode Corporation

APPENDIX B

SEMICONDUCTOR DEVICE ELECTRICAL PARAMETER SYMBOLS AND ABBREVIATIONS

SEMICONDUCTOR DEVICE ELECTRICAL PARAMETER

SYMBOLS AND ABBREVIATIONS

VG	Gate voltage
gm	Transconductance (FET)
gm_1/gm_2	Transconductance ratio (FET)
h_{FE}	Common-emitter static forward current transfer ratio (gain)
I_{CBO}	Collector cutoff current open emitter
I_{CEO}	Collector cutoff current (dc) base open
I_{CER}	Collector cutoff current (dc)
$I_D(off)$	Drain cutoff current (FET)
I_{DSS}	Zero-gate-voltage drain current (FET)
I_{DSS_1}/I_{DSS_2}	Zero-gate-voltage drain current ratio (FET)
I_{GSS}	Reverse gate current (FET)
I_{GSS_1}/I_{GSS_2}	Reverse gate current ratio (FET)
I_R	Reverse leakage current, diode
NOISE	Noise voltage at specified frequency (Hz)
$R_D(on)$	Drain-source on-state resistance (FET)
$R_{EC}(on)$	Emitter-collector (on) resistance
V_{DS}	Drain-source voltage (FET)
$V_{EC}(off)$	Emitter-collector (offset) voltage
V_{GS}	Gate-source voltage (FET)
ΔV_{GS}	Radiation-induced change in gate-source voltage (FET)
V_F	Forward voltage, IR-LED
V_R	Reverse voltage, diode
V_Z	Reference voltage, diode